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Managing Editor: J. H. Kusner, *University of Florida*

Associate Editors: G. L. LaFuze, *Stetson University*
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Florida Academy of Sciences
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PROCEEDINGS OF
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SOME OBSERVATIONS UPON THE USE OF MATHEMATICS IN THE SCIENCES*

R. C. WILLIAMSON
University of Florida

Because of the nature of the subject matter, mathematics has played a greater part in the development of the physical sciences than in biology and the social sciences. Particularly in the case of astronomy and physics, the two sciences have proceded hand in hand with mathematics almost from the very beginning. Most of the vast body of theory, however, has grown since the development of the calculus by Newton and Leibniz about 1670. The use of mathematics to any appreciable extent in the social sciences dates from the work of A. Cournot in the year 1838, with a steady development since. In the biological sciences, owing to the complexity of the task, other than in statistical methods, no great progress has been made in any application of mathematics to fundamental theory until the period since 1900. Within the last few years, some interesting beginnings have been made in this direction, to which I wish to refer later in the discussion.

Physics probably may be considered the most fundamental science (at least by the physicists), in that its principles, ideas and techniques are necessary in the development of all of the other natural sciences. The nature of its subject matter has made it peculiarly susceptible to the application of mathematical methods of analysis. The ability to simplify experimental conditions in fundamental experiments, thus rendering mathematical analysis possible; and then gradually to build up to more complex situations step by step, with experiment and theory moving along hand in hand, has constituted the great strength of physics and the advantage it has enjoyed over the other sciences in establishing satisfactory and accurate theoretical descriptions of natural phenomena.

For these reasons it may be profitable for us to consider some illustrations selected to bring out and clarify some of the advantages

*Address of the retiring president.

resulting from the use of mathematics in the case of physics, and then to follow with brief mention of some recent interesting applications of mathematics in biology and the social sciences.

At present the young man entering physics asks himself whether he wishes to be an experimental or a theoretical physicist. The mathematical and experimental techniques have become so extensive and complex that it is well-nigh impossible for one individual to encompass both. The experimental physicist must acquire sufficient mathematical readiness to be able to read the output of the theoretician and make the calculations for his own work, and similarly the theoretical physicist must acquire sufficient experimental background to be able to interpret the work of the experimentalist. We speak of "physicists" and "mathematical physicists"', and recently the term "mathematical bio-physicist" has been added to our lexicon.

There always exists the problem of how much of the preliminary training may be devoted to mathematics as against training in the methods of the science itself. This is a matter which must be left to the collective judgment of the scientists concerned. Some students can profit by more mathematics, and some by less. But whenever that rare individual appears who exhibits both an aptitude in mathematics and an enthusiasm for the methods and subject matter of the particular science, he should be cherished with great affection and encouraged to go ahead with his mathematical preparation,—he has the possibilities of making rare contributions to his science.

We may note that mathematical methods to a certain extent are a sort of symbolic shorthand with appropriate rules of manipulation, which render it possible to carry through extemely complicated chains of reasoning which would otherwise be quite impossible for the ordinary intellect. They enable one to extract the most from a set of observations or postulates. As Mark Twain says: "There is something fascinating about a science; one gets such wholesale returns of conjecture out of such a trifling investment of facts." Thus from an investment in Newton's three laws of motion and his law of universal gravitation, as expressed in two short equations, one may proceed by an application of the calculus to reap lordly returns in achieving the laws by which the celestial bodies swing through space in their eternal wanderings.

Frequently the decision between two alternative theories rests upon the outcome of a quantitative experimental check of calculated predictions by the theories. One classic illustration of this is in the case of the Rutherford theory of the nuclear atom (resembling the solar system) as opposed to the Thomson theory of an atom consisting of an extended sphere of positive charge within which the electrons

vibrate about. The Thomson atom had the advantage of providing a model which was statically stable, and in those days it was easier to conceive how the physical and chemical properties of matter could be accounted for in terms of this type of atom. But Rutherford made mathematical calculations of the angles through which alpha rays should be scattered when they were projected through thin metal foils. He made these calculations both for the nuclear model and for the Thomson spherical type. Then he carried out experiments, measuring the angles of deflection of the alpha rays, and found that the measured angles agreed with those predicted by the nuclear theory. Thomson and the other physicist of the day, being mathematicians also, recognized the cogency of Rutherford's calculations and experiments, and from that day the nuclear atom has served as the basis for all atomic models. Without the calculations and the measurements, the scintillations observed through the microscope upon the screen of his scattering apparatus were merely a beautifully mystifying play of flickering green will o' the wisps. In the hands of the mathematical physicist they established the foundations of one of our most fundamental conceptions of matter.

Often, as a result of mathematical considerations, a tremendously useful concept may be defined which has no intuitive counterpart. Consider for instance the physical concept "work", which is defined through the product of force times distance. Force and distance in themselves are intuitive ideas, but why should their product be especially important? However, calculations show that for the ideal machine the work output equals the work input; calculation and experiment show that when a moving force produces heat, there is always a constant amount of heat evolved for a given amount of work expended. And thus is evolved the idea of conservation of energy which is the basis of the whole science of thermodynamics with its tremendous power in making predictions about phenomena which are too complicated for any detailed mechanistic calculation. The development of practically all of our physical theory is dependent upon the simplifications offered by this function.

The calculation of magnitudes assists the imagination in building up the mind's pictures of the submicroscopic world of the atom and the molecule and the supermacroscopic conceptions of the stellar universe. By a combination of experiment and calculation we arrive at a picture of helium gas for instance as consisting of atoms resembling minute solar systems, at the center of each a nucleus whose diameter is approximately one ten thousandth the diameter of the orbits of its two electronic satellites. In the gaseous state these atoms are

separated by distances of approximately ten times the atomic diameters. These minute solar systems dart about with the speed of rifle bullets, colliding with one another and the walls of the containing vessel. And on the other hand as a result of astronomical measurements and calculations, one is led to visualise stellar systems at such distances that it may require millions of years for light to reach our system from them. Thus does mathematical physics constitute both the microscope and the telescope of the mind.

Frequently in a theoretical prediction, some vital factor has been completely forgotten or neglected. When a numerical experimental test is made, a discrepancy is discovered, and then in the resultant re-examination of the theory the missing factor is discovered. This, of course, has been the history of most of our theoretical advances. One simple classical illustration however is that of the discussion of the velocity of sound in gases. Sir Isaac Newton calculated that the velocity should be calculable as the square root of the pressure divided by the density. But this gave results which were about fifteen percent too low. Then LaPlace re-examined the argument and saw that Newton had overlooked the fact that as the sound compressions and rarefactions pass through the air the latter is adiabatically compressed and expanded, resulting in periodic heating and cooling. When the theory was corrected for this fact, the expression for the velocity became the square root of gamma times the pressure divided by the density, where gamma represents the ratio of the two specific heats of the gas. This formula gives accurate results, and as a matter of fact serves as a method of measuring gamma, so that from experiments in sound one measures a fundamental thermal constant.

Sometimes, in the case of very complex phenomena, we find that a very much simplified model may give us very good results within reasonable limits. Some of the most striking illustrations may be taken from the field of the kinetic theory of gases. Consider the pressure, density and temperature properties of a gas like hydrogen. If one tries to imagine in detail what is happening in the vessel, one thinks of each molecule as a pair of heavy positively charged nuclei with a pair of electrons revolving in some complicated fashion about the axis of the molecule. As each molecule darts through space it may be whirling rapidly like a dumb-bell thrown into the air and at the same time its atoms may be vibrating rapidly to and from each other. These whirling vibrating molecules collide with one another and with the walls. They may stick to the walls momentarily, shivering and vibrating violently, to be thrown off very quickly with a different motion from that which they approached the wall. Thus we have a picture of the mechanism of exertion of pressure; but how

to calculate it? Now, instead of trying to consider in all detail the behavior of these molecules on collision with the walls, we may try the assumption that we have a collection of point molecules having velocity and inertia, which are perfectly reflected from the walls. We then arrive by quite simple calculations at an equation representing quite accurately under ordinary conditions the variation of pressure with density and temperature. From the resulting equations the average speeds of the molecules can be calculated, and are found to agree quite accurately with those measured directly.

A training in mathematics inculcates the habit of careful examination of postulates and meanings of words and symbols used in reasoning. Thus frequently one finds that words are used carelessly with meanings accepted at an earlier period when the facts were not so well known or recognized. Or one may finally get a theory with so many ideas assumed tacitly or otherwise which gives so many results not in accord with experimental facts that it becomes useless for guiding experiment and needs to be revised. Thus Einstein in examining the foundations of dynamics was led to question the meaning of simultaneity and of absolute motion. As a result we have the birth of his theory of relativity. In the case of the classical quantum theory, at first the theory predicted many things which classical dynamics could not account for and was a striking improvement over the latter. Then after a time it was found that the results were wrong in many details when experiments were carried out to test the theory. This led Heisenberg to question whether the models of the theory did not contain more detail than was necessary to get results which could be tested by experiment. So he suggested restricting the theory to the minimum assumptions necessary to give predictions which could conceivably be tested by experiment and not to worry about trying to calculate things which we might imagine about atoms but which we could never hope to measure experimentally. As a result of his analysis from this viewpoint we have one of the beginnings of the development of the modern quantum theory which contains the good results of the old theory, and thus far has predicted accurately those properties of atoms and molecules for which it has been possible to carry through the calculations and make the observations. And a paradoxical result of this work is that with the newer and more accurate theory our conceptions of the atom have not become sharper and more precise, but have lost detail and become more blurred, much as when one passes from a painting by Meissonier, finished with almost photographic detail, to one of Corot's misty shimmering landscapes.

Considering mathematics as affording methods, symbols and rules for carrying on complex thinking processes, there will be different branches, each of which is best adapted for a particular type of thinking. Thus in any given scientific problem there will arise a need for the appropriate mathematics or logic. In most cases, as a result of the natural curiosity and activity of the mathematicians, one can usually find the necessary mathematical tools already developed. In some cases, however, it will be necessary to work out suitable mathematical processes and notation for the task in hand. As a classical illustration of this latter situation, we have the development of the methods of calculus by Newton and Leibniz. In considering the laws of motion, Newton found it necessary to investigate continuously variable physical quantities. In order to be able to predict resultant motions of bodies from given initial conditions, he developed the methods of the calculus. Leibniz at about the same time was worrying about similar questions and more or less independently worked out similar ideas, and went ahead and put the methods and notation of the calculus into practically the forms which are utilized today. One fairly recent illustration of a situation in which the mathematical methods had already been worked out from purely abstract grounds is found in quantum mechanics. Heisenberg and Born had been re-examining the foundations of modern atomic physics, and had encountered situations which called for what appeared to be rather unorthodox mathematical arguments. As they proceeded with the development of the logic, Born recalled a course in the theory of matrix algebra that he had taken in years past. Upon further investigation, they found that much of the mathematical material they needed was to be found in the treatises on matrix algebra.

Passing now to the consideration of the biological sciences, we note that because of the complexity of biological systems, and also because of the fact that the physicists and chemists have not completed the task of working out the laws of the physical and chemical properties of the substances with which the biologist must deal, any profitable applications of mathematics in biology, other than statistical, have been so difficult and offered so little promise that few have devoted themselves to the field. Passing over various statistical studies, we may mention the work of A. J. Lotka, of Johns Hopkins. In his book, *"The Elements of Physical Biology,"* he presents a study of the foundations of biological theory from the standpoint of mathematical physics and chemistry. With a substantial training in these fields, having studied under the celebrated English mathematical physicist, J. H. Poynting, Lotka has used the methods of the dynamics of constrained systems, of the thermodynamics of physical and chemi-

cal systems both in change and in equilibrium, and of the kinetic theory of collision and capture. He applies these ideas of the discussion of interactions of species, their growth, population equilibrium, evolution as a trend towards maximum utilization of energy which is in process of degradation, etc.

However, I wish more especially to call your attention to some recent work attacking the problem of setting up the foundations of mathematical biophysics by a group of men of whom Nicholas Rashevsky of Chicago is probably the leading exponent at the present time. Rashevsky has recently published two books summing up the results of this work, *Mathematical Biophysics* and *Advances and Applications of Mathematical Biology*.[1] Also a journal, *The Bulletin of Mathematical Biophysics,* carries much of their current work. Rashevsky is a mathematical physicist who for several years has devoted his attention to biophysics. The theory and techniques necessary are well developed in classical physics, so that it is mainly a question of assuming simplified models of biological systems, carrying through the necessary calculations which may be more or less tedious, checking predicted results with observations, revising models, recalculating, rechecking, etc., continually arriving at a closer approximation to the actual organism. In the meantime, the analysis serves to guide experimentation in many directions.

He begins with the cell, since it is the fundamental unit, in much the same way that the physicist works upon the properties of the atom in order to shed light on the structure and properties of gross matter. I should like to consider in some detail a few illustrations from his work, in order to give a more concrete idea of the kind of results that may be obtained in this manner.

First considering one of the simplest problems. He assumes a spherical cell surrounded by a permeable membrane immersed in a liquid containing various solutes. Also that there is an autocatalytic reaction of some of the solutes within the cell such that the rate of formation of a given substance is proportional to the amount of that substance present at any instant. This gives a straightforward problem in diffusion, with spherical symmetry. Setting up the differential equations and working out the results according to standard methods, he finds that the concentration of the resultant product of the reaction increases as the radius of the cell increases, and that above a certain critical radius the concentration becomes infinite, so that the cell could no longer exist. Using reasonable values for the various concentrations of the solutes initially, he finds that the critical radius is

[1]University of Chicago Press.

approximately one one hundredth of a centimeter, which is a quite satisfactory order of magnitude considering the assumptions.

Next, adding more detail to the picture, he assumes the membrane to be semi-permeable. Within the cell are small colloidal particles which catalyse reactions within the cell. Examining the forces involved in the cell, we see that there are forces upon the colloidal particles and the molecules of the liquid resulting from diffusion gradients which produce resultant pressures upon the surface membrane which tend to cause it to expand against the forces of surface tension. Treating it from the standpoint of energy, he carries the cell through a process of expansion to infinite size and recondensation into two half-cells. He thus gets an expression for the change in energy when the cell divides. He finds that this change is positive for a cell below a certain critical radius, and negative above. Thus above this critical radius the cell would be unstable, and would tend to divide. Taking plausible values for the various quantities involved, he finds that the critical radius is approximately one one thousandth of a centimeter, which is the average order of magnitude of cells. Thus he has a model which simulates the process of cellular multiplication.

Following this, he considers several reactions taking place within the cell, assuming for a particular case a simple splitting of glucose into lactic acid with subsequent oxidation. The outgoing and incoming metabolites will have opposing effects on the tendency toward division. He is able to get an approximate expression for these opposing tendencies in terms of the glycolytic coefficient, or the ratio of the number of lactic acid molecules produced to the number of oxygen molecules consumed. This expression shows that the greater the glycolytic coefficient in general the greater is the tendency toward division. He notes in this connection that the abnormally rapidly dividing cancer cells have been found to have a high glycolytic coefficient. The dividing factors would be the production of carbon dioxide and lactic acid. The stabilizing factors would be the inwardly diffusing glucose and oxygen. His results indicate that a lower sugar such as a pentose should give a greater stability than a hexose. Under certain conditions it appeared that an increase in the oxygen pressure surrounding the cell would give greater stability. In this connection he mentions work in which increased oxygen pressure had been used with some success in arresting cancer growth.

Time will not permit us to more than mention that he discusses briefly possible mechanisms of cell mitosis, gives a fairly detailed mathematical treatment of the various theories of nerve conduction, excitation, considers models for conditioned reflexes, the gestalt problem and rational learning and thinking.

Thus far we have been considering applications of mathematics in which the benefits derived resulted primarily from the *quantitative* aspects. However, in some portions of the various sciences there exist needs for logical schemes for following out *qualitative* deductions as to the relations between individuals and classes. Normally this is done using the ordinary language facilities augmented by special scientific terminology. However, because of the ambiguities which occur frequently in the language, and because of the great amount of verbiage which may be necessary, the following through of a chain of arguments may attain great length and complexity, so that it is difficult to follow, to say nothing of the danger of going astray because of ambiguites.

Now there is a branch of mathematics—call it mathematical logic, or symbolic logic, or the calculus of relations—with which probably few of us save the logicions or the mathematicians are familiar, even by hearsay. Quoting freely from Woodger[2], it had its beginning in a dream of Leibniz of a universal symbolic language capable of expressing the results of any branch of science, and of a calculus which would enable reasoning to be conducted in any sciences with the same precision as has been attained in the mathematical sciences. Developed by subsequent authors, and reaching its most complete summary in a monumental work by Russell and Whitehead entitled *Principia Mathematica*, it has made striking progress toward the goal of Leibniz. It is an endeavor to find the system of all mathematical systems. Thus, as an illustration, using only a few postulates, primitive ideas and propositions taken from logic, Russell and Whitehead are able to show that all the propositions of arithmetic must follow. A special notation has been evolved, which to the uninitiated person looks like a combination of cuneiform, Chinese, Roman and futuristic symbols. However, as Russell and Whitehead say, words and grammar have not the unique simplicity necessary to represent the few simple but exceedingly abstract ideas and processes used in the reasoning followed. The use of the symbolism in the processes of deduction aids the intuition in regions too abstract for the imagination readily to present to the mind the true relations between the ideas employed. The mind is led to construct trains of reasoning in regions of thought in which the imagination would be entirely unable to sustain itself without symbolic help. In a paradoxical play upon the abstractness of the ideas in which the mathematician frequently deals, Russell says that "mathematicians are people who never know what they are talking about, and do not care whether what they say is true."

[2]J. H. Woodger, *The Axiomatic Method in Biology* (Cambridge University Press, 1937), p. 14.

Now a biologist, J. H. Woodger, of the University of London, felt that in biology, as he says, there is a wealth of empirical data with little system; that many of the chronic controversies are traceable either to failure to eliminate metaphysical elements from biological topics or difficulties created by the current biological language; that with a perfect language there would be no need to dispute, only calculate and experiment. To him the methods of symbolic logic seemed well fitted to his purpose, so he took up the study of the work by Russell and Whitehead with the purpose of adapting it to the needs of biology. He becomes so enthusiastic about symbolic logic as a tool of investigation in science, in addition to the ordinary mathematical processes, that he says: "from the point of view of generality the essentials of the Principia Mathematica have as good, if not a better, claim to be taught in schools as the traditional algebra and geometry." As a result of his enthusiasm, we have his book *"The Axiomatic Method in Biology,"* from which we have been freely quoting, and in which he deals mainly with the adaptation of symbolic logic to problems of classification and Mendelian genetics. He first gives an outline of the elements of symbolic logic with its notation. Then he gives the various axioms together with resultant theorems necessary for investigation of various questions along with a suitable symbolic notation. Not all the theorems are proved, but a few illustrative proofs by symbolic methods are given.

Quite recently a group of men in this country, led by Clark L. Hull of Yale, have applied the methods of symbolic logic in psychology. Impressed by Woodger's work they undertook a study of the application of these methods to the problem of Rote Learning. The results of their work are published in a book entitled *"The Mathematico-Deductive Theory of Rote Learning."* To quote some of Hull's remarks as a result of their experience, "The great reason why *qualitative* postulates are so unsatisfactory is because they have so little deductive fertility . . . . One of the most important reasons for this relative sterility in behavioral situations is that very commonly action potentials of opposing sign are operative simultaneously, and the theoretical outcome is dependent upon which of the opposing potentials is dominant. This dominance cannot be determined until the amount of each separate potential can be represented by exact symbolism. When the postulates can be written out in equations . . . . and when in addition the constants making up important portions of the equations are known from empirical determinations, the rich store of devices which mathematicians have invented at once becomes available. Judging from our experience with the present system, the change from qualitative to quantitative postulates with

known constants increases the fertility of the postulate set between ten and fifty times." The project was a collaboration of six men, psyschologists and mathematicians, with a procedure somewhat as follows: the psychologists would hand the mathematicians a tentative set of theorem propositions, with a request to derive them from a set of behavioral postulates and definitions previously formulated. The mathematicians then, using the methods and symbolism of symbolic logic, would derive the theorems or send them back when necessary to the psychologists because the theorems had been found to be inconsistent with the postulates. In the latter case they would be recast and returned to the mathematicians. In the monograph, after outlining the experimental procedure in carrying out the tests in Rote Learning, they give parallel statements in ordinary phraseology and in symbolic notation of the primitive and associated defined terms. Then follow some eighteen postulates. On the basis of these definitions and postulates fifty-four theorems and many corrollaries are derived. Hull closes the work with these remarks: "despite its evident difficulties, we hope that it will at least serve as a concrete large scale demonstration of what we mean when we speak of systematic theory in the social sciences. It expresses our conviction that only by using the logical as well as the empirical component of the complete logico-empirical methodology will the social sciences approach the predictive power and practical significance now characteristic of the physical sciences. It is true that behavioral phenomena are more complex and problems involving them are more difficult of solution. This but emphasizes the need of the social sciences for the most powerful tools available."

Passing now to economics, the use of mathematics to any appreciable extent had its beginning in the work of Augustin Cournot, in a treatise on the "Mathematical Principles of the Theory of Wealth" in 1838. He was an able mathematician, having been professor of mathematics at Lyons, and he published a number of papers in mathematics as well as in economics and logic. As Cournot says, "this work sets forth not only theoretical researches, it shows that I also intend to apply to them the forms ond symbols of mathematical analysis . . . . a plan likely, I confess, to draw on me at the outset the condemnation of theorists of repute. The solution of the general questions which arise from the theory of wealth depends essentially not on elementary algebra but on that branch of analysis which comprises arbitrary functions which are merely restricted to satisfying certain conditions . . . . the first principles of differential and integral calculus suffice for understanding this little treatise." Cournot's work is classic,

and provided the essential basis of much of the work of later economists.

Closely following Cournot came Jevons and Walras, of England and France respectively, both using mathematical methods quite independently of each other, but paralleling in many of their results, developing the idea of marginal utility and using it as the basis of their theories. Jevons was quite an ardent crusader in behalf of the use of mathematics, though Walras seems to have made more extensive use of it. As Jevons says: "my theory of economics is purely mathematical in character. Nay, believing that the quantities with which we deal must be subject to continuous variation, I do not hesitate to use the appropriate branch of mathematical science, involving as it does the *fearless consideration of infinitely small quantities.*" We might interpolate here that a certain school of modern governmental economists seems equally fearless in the contemplation of infinitely large quantities.

Succeeding these men, there have been many following in their steps in considering fundamental economic theory with a *fearless* use of the appropriate branches of mathematics. And of course, in addition to this theoretical work there is the enormous amount of statistical work which is carried on continually by private, educational and governmental agencies.

As a result of all this, we find books written especially for the economists in which the most frequently used portions of mathematics have been selected and presented together with illustrative problems chosen from economic fields. By scanning briefly some of the more important section headings in a recent book of this type by R. G. D. Allen, of the London School of Economics, "*Mathematical Analysis for Economists,*" we can form an idea of the scope of the mathematics employed most commonly. We note:—functions and their diagrammatic representation, analytic geometry, derivatives and integrals, maxima and minima, differential equations, infinite series, calculus of variations, and determinants.

I shall not attempt to follow out this question any further, but I think it may safely be said that as time passes the pages of the economics journals and texts will continually find a more liberal sprinkling of mathematical symbols possibly to the point of rivaling the situation in physics and chemistry.

Before closing, I should like to call attention to the fact that Rashevsky has been led into the field of social science by a continuance of his work upon biological theory, in that as he passes from the single cell to aggregates of cells he naturally comes to the question of the behavior of complex organisms, such as man, in their reactions to each other and their environment. He argues that in the same man-

ner in which the purely abstract geometries of Euclid, Lobatschevsky and Riemann have proved to be of utility in applied theories (for instance much of Einstein's work would have been impossible without Riemann's previous developments), so an abstract theory of possible human relations is desirable before concrete theories can be fully developed. On simple assumptions as to influences of individuals on each other's activities, he is led through work involving integral equations to formulae on class stability, etc.

Also, in a more personal sense, I should like to mention that one of our own members, Dr. M. D. Anderson, has published a number of papers, making a free use of mathematics, treating the fundamental theory of Savings and Investments, Distribution of Wealth, Wages, and Employment. I believe, also, that here we have another happy illustration of cooperation of the departments of Economics and Mathematics.

In closing, I should like to acknowledge gratefully my indebtedness to our fellow members of the Academy, M. D. Anderson, R. F. ellamy, J. H. Kusner, for ideas developed in discussion and for suggestions as to reference material.

NOTES ON THE EMERGENCE AND LIFE HISTORY OF THE DRAGONFLY PANTALA FLAVESCENS

C. Francis Byers

Department of Biology, University of Florida

During the closing months of the year 1939, an unusual opportunity arose to study with some precision certain aspects of the metamorphosis and life history of one of the most omnipresent dragonflies—*Pantala flavescens* (Fabricius).

At this time, the cast skins (exuviae) of the larvae (nymphs) of this dragonfly were appearing in large numbers on the walls of Glen Springs—a sand-bottom, spring-fed, swimming pool near the University of Florida Campus. Not only was the location close enough to visit frequently, but the pool presented an enclosed environment, limited and exact in area, depth, water volume, etc., that could be studied with comparative ease. Moreover, the emerging nymphs, representing quite a population, were all of this one species. While adults of quite a number of other species of Odonata were flying over the pool only *P. flavescens,* one of the hardiest of known dragonflies, was using it for breeding purposes.

Some previous work has been done on phases of the natural history of *Pantala.* C. B. Wilson[1] has observations, included along with other species of Odonata, on the number of cast skins, breeding habits, etc. Laura Lamb, in 1925[2] and 1929[3], has published the results of her research on the larval stages of *Pantala,* including information on the number of instars, length of nymphal life, etc. Other writers have contributed also.

It is my desire to supplement and check this work (especially the work done in the laboratory) from direct field observations made by means of the favorable conditions existing at Glen Springs, where some quantitive information seemed to be available.

My chief regret is that my data should have to be published after only one year of work. Repair activities of the pool, especially the cementing of the bottom, made it impossible to carry on for

[1]C. B. Wilson, "Dragonflies and Damselflies in Relation to Pondfish Culture, With a List of Those Found Near Fairport, Iowa," *Bull. Bureau of Fisheries,* Vol. 36, Document No. 882 (1920), pp. 182-260.

[2]Laura Lamb, "A Tabular Account of the Differences Between the Earlier Instars of Pantala Flavescens," *Trans. Amer. Ent. Soc.,* Vol. 50 (1925), pp. 289-312.

[3]Laura Lamb, "Later Larval Instars of Pantala," *Trans. Amer. Ent. Soc.* Vol. 55 (1929), pp. 331-334.

the two or three additional years that would perhaps have succeeded in bringing facts and figures to answer the many questions still in doubt.

PANTALA FLAVESCENS

Pantala flavescens was described under the name *Libellula flavescens* by Fabricius in 1798 and was placed in the genus *Pantala* by Hagen in 1861. The nymph was first characterized by Cabot in 1890 and was more fully described by Needham in 1901[4]. The genus contains one other species, the American P. *hymenea* (Say).

Pantala belongs to the dragonfly family Libellulidae and together with such genera as *Tramea*, *Macrodiplax* and *Miathyria* constitutes the most highly specialized and evolved group within the order Odonata.

P. flavescens is, in general, a cosmopolitan dragonfly generally rare but occuring sporadically in large numbers; is usually most abundant in the summer and early fall. It is a diurnal species most frequently associated with ponds, marshes, or open fields.

Muttkowski[5] gives the distribution of *P. flavescens* as follows:

"Cosmopolitan (circumequatorial); all continents, except Europe (Italy?); N. Amer.: Alleghanian to Tropic; Me. & N. Dak. to Cal. & Fla.; W. Indies; Mex., C. Amer."

Dr. Needham[6] writes about this species as follows: "as reported not only from all parts of the globe but from nearly all varieties of habitat. Muttkowski has found it flying from July to September near rivers, lakes, ponds, in woods, and in open places. Davis has seen it flying in great numbers over an oat field, and has observed a female ovipositing in a ditch of brackish water by a roadside."

F. C. Fraser[7], writing on the Odonata of Samoa remarks, "Many specimens (were) taken principally during September, when the species indulges in migration."

Davis and Fluno[8], in discussing the Odonata of Winter Park, Florida, state that *P. flavescens* is, "Fairly common at various times, Apr. to Dec."

I have captured adult *P. flavescens* in Alachua County, Gainesville, Florida, from July to December, but until the Glen Springs ma-

[4]James G. Needham, "Aquatic Insects of the Adirondacks," *Bull. N. Y. State Museum,* No. 47 (1901), pp. 384-596.

[5]R. A. Muttkowski, "Catalogue of the Odonata of North America," *Bull. Public Mus. Milwaukee,* Vol. 1 (1910), pp. 1-207.

[6]James G. Needham and H. B. Heywood, *A Handbook of the Dragonflies of North America* (Springfield, Ill.: C. C. Thomas, 1929).

[7]F. C. Fraser, *Insects of Samoa*: *Odonata* (London: William Clowes Sons, 1927).

[8]E. M. Davis and J. A. Fluno, "The Odonata of Winter Park, Florida," *Ent. News,* Vol. 49 (1938), pp. 44-47.

terial turned up, have not found either adult or numph in large numbers. In addition, I have records for the species from Manatee and Dade Counties, also ranging from July to December; records from Key West made in July; and some specimens taken, along with *P. hymenea,* at Ware Shoals, South Carolina, as early as the last week in June.

The adults and nymphs of this species are easy to identify, being conspicuously marked and quite distinct.

GLEN SPRINGS

Glen Springs is a swimming pool located about one mile north, on U. S. 441, and a half-mile west of Gainesville, Florida. The pool is fed by a spring, which is a part of it, and is situated in a wooded ravine. The pool overflow forms a sand-bottom stream meandering through a magnolia hammock.

The swimming pool has an over-all measurement of approximately 40 x 300 feet and contains roughly 500,000 gallons of water, with a rate of flow of 10,000 gallons an hour. The pool is divided into three sections, each of which is rectangular in shape and somewhat angled in relation to the others—thus the three rectangles do not lie in a straight line. The deep section is 40 x 125 feet and has water 7-10 feet deep. The central section is 40 x 100 feet and has water 3-5 feet deep. The shallow section is 75 x 40 narrowing to 35 feet and has water 2-1.5 feet deep. At the end of the shallow portion is the spring.

The walls of the pool are of cement with cross-walls separating the three portions. The flow of water is uninterrupted between the three sections. At the time this study was undertaken, the bottom of the pool was of white sand. During the summer of 1940 a cement bottom was put in and extensive repairs were made. This work was started in April and was not completed until August.

Glen Springs is regularly open for swimming from May until about the middle of September. During the swimming season the pool is drained once a week and the walls are cleaned. In addition, "Perchloron" a commercial product containing not less than 70% calcium hypochlorate was used once a week as a water disinfectant. Thus during the summer the pool was devoid of aquatic life as far as appearances could be relied upon.

OBSERVATIONS ON EMERGENCE

On September 28, 1939, in search for Protozoa culture for a Biology laboratory, I visited and first noted the cast skins of *Pantala flavescens* clinging to the walls of the Glen Springs swimming pool. Again, on a like mission, I saw them now quite numerous, in middle October. However, it was not until the middle of November that

time and opportunity allowed me to collect these cast skins and begin the day-by-day observations upon which this paper is based.

On November 11, 1939, all the cast skins on the north walls of the three sections of the pool were gathered, a total of 150 (see table).

From November 11, until the last skin appeared, almost daily visits were made to collect the new crop of exuvia. On each visit the walls would be cleaned of the current crop. On some days as many as two or three visits were made to check on time as well as rate of emergence. Data were obtained on: (1) the number of cast skins appearing daily on the three sections of north wall (2) the number of nymphs in the process of emergence (3) the number of dead and alive adults of *Pantala* around the pool (4) other adult Odonata in the pool's environs (5) the accumulating aquatic life within the pool, which became rapidly more abundant and complicated as the pool ceased being used (6) the time of day, temperature, and general weather conditions.

On December 9, as the wave of emergence began to decline, I gathered the cast skins from the remaining walls of the three sections of the pool. From the *south, east, west* walls (there were no skins on the cross walls separating the pool's sections) 291 skins were obtained (see table).

From December 9 to December 23 records of emerging nymphs were obtained for the east, south and west walls as well as for the north wall (see table).

The last nymph emerged on December 23. From that date until January 20 the frequent visits were maintained. After January 20 the number of visits were cut down to one or two a week until repair work began on the pool in April. During the late spring, the summer and the fall of 1940, visits continued at the rate of about once a week, but somewhat irregularly spaced, to check on appearance and possible mating and egg laying of adult *P. flavescens*.

The pool was drained for first time since swimming had stopped in September on February 13, 1940. At this time the bottom and the accumulated algal mats were carefully examined for Odonata larvae. No dragonfly larvae of any species were found. The pool was again drained on March 19. Another examination of the bottom again failed to reveal any sign of Odonata larvae. On April 10, the pool was finally drained for the work of cementing the bottom, thus destroying any chance of repeating my 1939-40 observations in subsequent years.

The following table gives the important data obtained in this study. Additional data used in this paper are recorded in my field notes covering the period of the study.

TABLE 1.—*Pantala* Record from North Walls of Glen Springs

Date	Time	T	DS	CS	SS	Emerging Adults Part	Entire	Temp. Mx.	Mn.	Days
		Cast skins[9]								
Nov. 11	10:30 AM	150	103	43	4			84	60	sun
" 11	2:00 PM	0	0	0	0					"
" 12	9:30 AM	5	3	2	0			83	63	"
" 12	12:00 N	0	0	0	0					"
" 12	5:00 PM	0	0	0	0					"
" 13	10:00 AM	1	1	0	0			61	59	rain, wind
" 14	10:00 AM	4	2	2	0			75	56	clear,wind
" 14	2:30 PM	2	2	0	0					sun, wind
" 15	10:15 AM	6	3	3	0			78	59	sun
" 16	10:30 AM	4	1	2	1					"
" 16	2:30 PM	0	0	0	0			78	62	"
" 17	10:45 AM	3	1	2	0			74	64	"
" 18	11:00 AM	4	3	1	0			80	63	heavy rain
" 19	10:30 AM	4	1	2	0	1 alive		75	59	sun
" 20	10:30 AM	14	6	6	2		3 dead	73	48	"
" 21	10:30 AM	17	8	5	1	3 alive				"
" 21	2:30 PM	5	0	4		1 dead		66	52	"
" 22	10:30 AM	15	8	5	2			65	37	"
" 24	3:00 PM	13	4	4	3	2 dead		66	43	cloudy
" 25	1:15 PM	2	1	0	0	1 alive		63	52	" , wind
" 26	10:30 AM	5	4	1	0			58	38	" "
" 27	10:15 AM	9	6	3	0		5 teneral	67	29	sun
" 28	10:30 AM	1	0	0	0	1 dead		75	36	"
" 29	1:30 PM	5	1	2	0	2 alive		76	46	"
" 30	10:30 AM	5	2	2	0	1 dead	1 "	78	55	"
Dec. 1	1:30 PM	10	4	4	2		1 "	72	60	"
" 2	11:00 AM	6	5	1	0		4 "	62	40	"
" 3	10:00 AM	4	3	0	0	1 dead		65	35	"
" 4	10:30 AM	1	0	0	0	1 dead		69	42	"
" 5	11:00 AM	1	0	1	0			76	47	"
" 6	10:30 AM	1	0	0	1			76	41	"
" 7	10:00 AM	1	1	0	0			75	44	"
" 9	5:00 PM	5	4	0	1			76	54	"
" 10	11:00 AM	6	3	1	0	2 dead		78	56	"
" 11	1:00 PM	5	3	1	1			72	48	"
" 12	3:00 PM	1	1	0	0			75	44	cloudy
" 13	3:00 PM	1	1	0	0			63	37	sun
" 14	11:00 AM	0	0	0	0			74	52	"
" 16	11:00 AM	2	0	1	1			75	52	"
" 17	11:00 AM	0	0	0	0			77	48	"
" 18	2:00 PM	0	0	0	0			79	55	"
" 19	11:00 AM	0	0	0	0			65	60	"
" 20	11:00 AM	0	0	0	0			68	39	"
" 22	11:00 AM	1	1	0	0			72	42	"
" 23	10:30 AM	2	2	0	0			72	59	"

[9]Under the column headed "cast skins": T=total number collected on the day in question. This included both cast skins and partially emerged adults, but does not include adults entirely emerged. DS, CS, SS=skins from deep, central and shadow sections of the pool respectively. The temperature readings were made at University of Florida Experiment Station by Prof. J. R. Watson.

TABLE 1.—(Continued)

Date	Time	Cast skins[9] T	DS	CS	SS	Emerging Adults Part	Entire	Temp. Mx.Mn.	Days
" 24	10:30 AM	0	0	0	0				
Dec.25-Jan.20	.....	0	0	0	0			.....	
Pantala Record from South, East and West Walls									
Dec. 9	as above	291	163	87	41			as above	
" 10	"	3	2	1	0			"	
" 11	"	4	1	2	1			"	
" 12	"	8	5	3	0			"	
" 13	"	0	0	0	0			"	
" 14	"	0	0	0	0			"	
" 16	"	0	0	0	0			"	
" 17	"	2	0	2	0			"	
" 18	"	1	1	0	0			"	
" 19	"	2	2	0	0			"	
" 20	"	1	1	0	0			"	
" 22	"	0	0	0	0			"	
" 23	"	1	1	0	0			"	
" 24	"	0	0	0	0			"	
Dec.25-Jan.20	.....	0	0	0	0			.....	

The total number of skins collected during the fall of 1939 (Nov. 11-Dec. 23) was 634, distributed as follows:

Skins on north walls Nov. 11	150	
Skins collected from north walls Nov. 11 - Dec 23	171	
North walls total=		321
Skins on remaining walls Dec. 9	291	
Skins collected from remaining walls Dec. 9 - 23	22	
		313

Because of the protected nature of the walls of the pool, the above figures probably are quite accurate. Some few skins undoubtedly were lost but these could not have been many.

The place of maximum emergence was the deep section of the pool. Primarily, the shallower waters of the deep section (7-8 ft.) and, secondarily, the deeper waters of the central section (5 ft.) gave the largest yield. The distribution in the three sections is as follows:

Skins collected from deep section (DS)	364	(57%)
Skins collected from central section (CS)	193	(29%)
Skins collected from shallow section (SS)	61	(10%)

The flow of water from the shallow to the deep section would in part account for this distribution, but, I believe, only in part.

The daily average rate of emergence was between 4-5 skins[10]. The maximum emergence observed was between November 20-24 and again on December 1.

It is of interest to note here that the nymphs for the next day's crop could be seen clinging to the walls a few feet below the water level. This was particularly true for observations made in the afternoon. The nymphs would swim close to the bottom and on contacting the base of the walls begin slowly to climb them, coming to rest as they neared the water line.

Emergence usually took place either at night or, most probably, in the early morning. However, an examination of the table will indicate that this was not always true. Thus on:

Nov. 14, 4 skins were collected at 10 AM. and 2 more at 2:30 PM.
Nov. 19, 1 of the four collected was seen emerging at 10:30 AM.
Nov. 21, 3 of the 17 collected were seen emerging at 10:30 AM. and at 2:30 PM. 4 additional skins were collected, one of which contained a partially emerged but dead adult.
Nov. 25, 1 of the 2 collected was seen emerging at 1:15 PM.
Nov. 29, 3 of the 5 collected were seen emerging at 1:30 PM.

Emergence mortality was low. Less than one quarter of one percent (9) died during the process of transformation and only three dead tenerals were seen, these floating on the water. Of the 16 partially emerged adults listed in the table, 6 were collected dead and 3 died during the next 24 hours. In all cases, nymphs in the process of transformation were circled with a pencil mark on the wall, dated and left until either dead or completely emerged. Usually death occured when the adult had emerged to the point where the top of the head and thorax were out of the skin, but legs, wings and abdomen were still in.

The partially emerged adult taken on November 28 was of special interest because it had begun to emerge about a foot below the water line and had progressed to the head-thorax point before death overtook it. On that day the air temperature was colder than the water and no other skins were found. Usually, of course, the nymph, before beginning transformation, would crawl well above the water level, a few inches to a foot or more. At times cast skins would be found clinging to each other three and four deep.

This low emergence mortality is somewhat at variance with commonly accepted notions which stress the great danger to the dragonflies at this point in their life history. The nature of the environment

[10]If this rate prevailed prior to Nov. 11, emergence began about September 11 or some 60 days previous (counting 150 skins from north walls and 142 from remaining walls for Nov. 11). This date tallies with the time the pool was closed for swimming.

in the present case is partially responsible for the low number of casualties; the lack of a shore fauna and of aquatic predators would contribute substantially to this result. Also, *Pantala flavescens* is a highly successful species of dragonfly and perhaps owes this success in part to inherent vigor and ability to withstand adverse conditions in general. Pre-emergence mortality was impossible to determine. However, no dead nymphs were found which had not at least started to transform. It would be interesting to make a comparative study with other species of Odonata under similar conditions to check these findings.

With the exception of the one nymph just mentioned (which began emergence under water), temperature and general weather conditions seemed to have no direct correlation with emergence. Tendencies were noted, always with exception, that cool and cold weather was associated with decline in rate of emergence, with late morning and afternoon emergence, and with increased mortality. The table gives the maximum and minimum daily air temperatures. No attempt was made to get water temperature. However, as the pool is spring fed, the temperature of the water should not vary much; except for the top few inches, it was probably between 78-80° F.

OBSERVATIONS ON LIFE HISTORY

Emergence is only one of the events in the life history of the Odonata. Mating, egg-laying, development of the egg and nymph, the natural history of the nymph and adult, and the length of the life-cycle are other aspects of the story.

Adult *P. flavescens* were rarely seen at Glen Springs and its neighboring territory. During the year or more of observing, no adults beyond the teneral stage of development were seen flying around or over the pool. Twice adults were observed along the road leading to the springs, both times in September, 1940.

In the few instances where transformation was actually watched, as soon as the teneral (soft) adults were fully hardened they would fly off toward an open field and disappear. What eventually happened to the 600 or more that thus left the pool's environs, I do not know. One guess, which is only partially satisfactory, is migration. However, I have no data to support this contention other than seasonal periodicity of the species and the remarks of other authors. One thing is certain, these adults moved away from the area of the pool and its surrounding territory, thus mating and ovipositing were not observed taking place at Glen Springs.

For Odonata nymphs, the more important factors brought about by the unique nature of the pool were created by the drainage and

sterilization of the water during the summer season and by the source, nature and amount of food.

The weekly draining and sterilizing could not have been insuperable barriers to the existance of very young nymphs of *P. flavescens* as many nymphs had completed their development and were ready for metamorphosis about the time that the pool was closed for the season. The draining was never so complete as to allow the sand of the bottom to become completely dry and while these nymphs are not sand burrowers (like *Progomphus* for example) they could have existed in the loose wet sand and perhaps have fed on organic material caught in it. The sterilizing also may not have been fatal to more than a portion of the population. Thus eggs deposited in the pool during July and August, the most probable time, had, almost certainly, to survive and hatch in some numbers at least.

The food problem is another matter. During July, August and early September available food for the later instars must have been wanting or very rare and even for early instars could not have been overly abundant. From middle September until the pool was drained in February the food supply increased in kind and amount until the environment was more similar to that of a natural pond. There was therefore no food problem for nymphs coming on toward maturity during this later period.

C. B. Wilson[11], Alfred Warren[12] and others have made studies of the food habits of the Odonata nymphs. Warren found that the nymphs of *P. flavescens* would eat practically anything given to them when they were fed under confined artificial laboratory conditions probably less rigorous than those prevailing at Glen Springs during the summer months. To establish the normal food habits, Warren examined the alimentary canals of 253 Odonata nymphs (*Anax junius* and *Pantala flavescens*) and published an extensive list of aquatic organisms found therein. His list includes Mollusca (*snails*), beetles (*Dytiscidae*), chironomid larvae and adults, mosquito larvae and adults, other flies, bugs, Crustacea (*Cypris* and shrimps), other Odonata and Protozoa. C. B. Wilson[13] published a more detailed list which includes the above and other aquatic organisms. From these studies the leading articles of diet seem to be algae, protozoa, snails, and chironomid larvae.

Laura Lamb[14] while studying the early larval instars of *P. flavescens* stated, "During the first instar no food was given; during the second and third instars *Paramecium* and small mosquito larvae formed the

[11]*Op. cit.*

[12]Alfred Warren, "A Study of the Food Habits of the Hawaiian Dragonflies or Oinou," *College of Hawaii* Pub., Bull. No. 3 (1915), pp. 1-45.

food. The remaining stages fed upon mosquito larvae and small crustaceans until the tenth instar, when pieces of earthworm and may-fly larvae were supplied. In the eleventh instar a small fish was eaten."

These accounts of the food habits indicate the existence of starvation conditions at Glen Springs until the middle of September. When I first visited the pool on September 28 it was for the purpose of obtaining protozoa material and the water samples taken into the laboratory were fairly rich in both ciliates and algae (mostly diatomes).

By mid-November, algae were abundant with thick, heavy submerged mats of the filamentous types forming. Adult chironomids were common on the walls of the pool above the water level. Late in November and continuing until about December 15 there was a heavy emergence of may-flies (*Callibaetis floridanus*), a species which, I am told, has one of the shortest (5-6 weeks) cycles of the group. In late November snails (*Planorbis*) made their appearance and became fairly plentiful. A few cray-fish (*Cambarus clarkie peninsularus*) were noted in December and January as were also some small fish. Gyrinidae were common on the surface from October on. Spiders were on the walls most of the time but apparently did no harm to the living dragonflies.

The 634 cast skins collected at Glen Springs represent that many successful larval lives which means that at least some 292 (approximate numbers on the walls on Nov. 11 when daily collecting began) of them must have started life under extremely adverse conditions, with only one factor in their favor—the lack of predators. Perhaps they all started out together, the result of one ovipositing female (the rarity of adults would suggest this) and the late comers were the less hardy and slower developing. Thus due to drainage, sterilization and early lack of food the pre-emergence mortality may have been great.

How many days does *P. flavescens* require to develop from the egg to the time of metamorphosis and through how many instars does the growing nymph pass? The most exact information on this question is given by Laura Lamb[15]. Lamb concludes that there are twelve instars in all. She found that the first batch of material that she worked with[16] took 90 days to reach the 10th instar and pass into the 11th (at which time they died). The 12th instar[17] required 30-32 days—"which would be one-fourth of the total life of the nymph." She would thus assign approximately 120 days or four months for the life-cycle.

[13]*Op. cit.*

[14]*Op. cit.*

Warren[18] gives the number of instars for his Hawaiian material as 10-12 which were passed on an average of 80 days, or only two-thirds as long as Lamb's Pennsylvania specimens.

What effect does temperature and available food have on the number of instars and the length of time required for the life-cycle? Lamb believes that there may be some correlation and states, "This difference in time of year (at which material was collected) might make some unexplaned differences in the number of days." A comparison of Lamb's and Warren's figures also tends to make one believe this might be true.

In view of the above, the Florida material would probably have a shorter cycle. However, it must be remembered that the Glen Springs water temperature did not fluctuate (except at the surface) very much, but that the available food supply was lowest in July, August and September, becoming plentiful from October on.

The first cast skins were seen at Glen Springs on September 28th (some may have been present a week or so earlier). Thus, some eggs must have been laid not later than the second week of July—about the time at which adults are usually first seen in this part of Florida. Assuming this, development must have been going on while the pool was still being used for swimming.

The last cast skin was collected on December 23rd and when the pool was drained in February no nymphs were present in the bottom sands. The eggs from which the December nymphs developed could have been laid at the same time as those giving rise to the September crop, providing adverse conditions could retard some individuals that much; they could not have been laid much later than October 1st (84 days).

We know, from the fact of its wide geographic distribution, that *P. flavescens* is an extremely hardy and ecologically tolerant animal; also, from the work of Lamb and Warren, that the life-cycle is quite short (the usual Odonate cycle is given as 18 months). This, along with these observations made at Glen Springs, indicates, beyond doubt, that the species has amazing powers of adaptability—it was the only dragonfly breeding in the pool[19].

[15]*Op. cit.*
[16]*Op. cit.*
[17]*Op. cit.*
[18]*Op. cit.*

[19]The thought was suggested that the eggs of *Pantala* were not laid in the pool but were carried in by the springs, by way of underground waters. This is possible, but my observations of the springs themselves make it hardly probable. At no time did cast skins appear on the walls surrounding the springs proper, either last year or this (the cementing of the pool bottom did not affect the springs). Also, as the water is very clear, nymphs could easily have been seen if they were present. Again, why one species only, if carried in?

OTHER DRAGONFLIES

As already indicated, no larvae of the order Odonata were found at Glen Springs except those of *P. flavescens*. However, during the time I spent at the pool, I observed quite a list of adult dragonflies and damselflies—usually the common ones that were seasonably abundant such as *Anax junius, Tramea carolina, Pachydiplax longipennis, Mesothemis simplicicollis, Ischnura ramburii, Argia fumipennis,* etc. Among the more interesting adults taken were:

Enallagma cardenium	on Dec. 3, 1939.
Hetaerina titia	on Dec. 4, 1939.
Somatochlora filosa	on Dec. 12, 1939.
Cordulegaster maculatus	on Aug. 12, 1940.
Progomphus obscurus	on Aug. 12, 1940 (an unusually late date).

These dragonflies represent a stream fauna and were probably breeding in the stream below the pool.

VISUAL EDUCATION IN THE BIOLOGICAL SCIENCES

Jay F. W. Pearson
University of Miami

Most workers in the field of biology have been inclined to look with sympathy upon those interested in the life sciences who are forced to display their efforts to the public. Such displays have, for the most part, in America, been handled by our landscape gardeners, our circuses, our zoos, and our natural history museums. Some biologists have been gifted in the art of writing for the layman, and the public has thus had some insight into biological studies that it would otherwise not gain. However, our biologists as a group have been rather inarticulate, and have confined their efforts to scientific publications and the satisfactions resulting from a job well done in the laboratory and suitably reported in some journal or at some scientific meeting.

The result has been that most Americans confuse the field of biology with the field of chemistry, and think that the biologist is either an animal trainer, or someone who works with test tubes, in accord with the best advertisements which picture scientists at work demonstrating the value of certain commercial products.

It was my privilege, in 1933, to pioneer the demonstration of certain biological principles and processes to many millions of people, by way of the biological exhibits shown in the Hall of Science of A Century of Progress at Chicago during that summer and the summer of 1934. Certain highlights of this work have been reported elsewhere.

In February of 1938 I was called to the University of California at Berkeley, to take charge of the biological exhibits in science which were to be prepared by the University of California, as part of the basic science section of the Golden Gate International Exposition, held on Treasure Island last summer and continuing through this summer.

Though the time for preparation was limited to one year, and funds and space were both reduced from the amounts available at Chicago, it was possible to bring together a visual demonstration of certain highlights of various biological sciences, which, in many ways, proved to be an improvement over the initial effort as produced at Chicago several years earlier.

Sections or exhibits were drawn from the fields of anthropology, geology and paleontology, zoology and oceanography, evolution and heredity, botany, and medicine. Exhibits were also prepared in the

physical sciences, but these were not my primary concern, being competently handled by other men.

At Chicago the goal had been to "tell a story" selected from each of the sciences. At Treasure Island, it was possible to tell certain stories, but more often it was more effective and more feasible to highlight certain principles or interesting features drawn from the sciences mentioned, and present them in such a way that the visitor, through these visual efforts, would gain some knowledge about some one fact or phenomenon. The visitor then would realize the wealth of research that has been carried on by the sciences. He would understand clearly that each of the fields of science illustrated could command the respect of every thinking person, whether he had been trained in science or whether his life interests had been guided in other directions.

Insofar as funds and space were available, I made every effort to provide color, attractiveness, and human interest, making the exhibits dynamic, and giving the visitor an opportunity to participate in them if it proved feasible.

Color was handled lavishly, to give variety and interest. So-called "rules" concerning the legibility of colored letters, as advanced by some psychologists, were broken at every turn, to give variety to hand-lettered panels. White letters were used on black, blue and green. Yellow letters were used on various shades of blue, green, and red. Black letters were used on any background, as needed.

Painted murals and panels and transparencies were placed against backgrounds of many different colors. A hundred and forty-five transparent, colored photographs, properly illuminated, added light as well as color to the displays.

The exhibit structure itself was handsomely colored, while the presence of carpet on all floor-space added to the appearance of the exhibit and to the comfort of visitors. Indirect lighting was the rule, with most counter exhibits mounted at a height of three feet and a half for easy viewing.

To better illustrate the type of exhibit presented we may use the Botany Section as an example. The first unit in Botany dealt with the reproductive functions of the flowering plants. The major feature of this exhibit was a large mechanized panel which I had built for A Century of Progress and was able to rent back from its purchaser, the Buffalo Museum of Science. This large panel showed a cluster of three giant gladiolus flowers, with one flower sectioned to show stamens and pistil, the male and female flower organs. When the visitor pressed a pushbutton at the rail protecting this exhibit, a pollen grain moved down from the anther and came to rest on

the stigma of the pistil. A lighted slot representing the developing pollen tube then began to grow down the pistil until it reached an ovule in the ovary. At this point a transparency in the side of the panel was lighted, showing an enlarged drawing of the details of the ovule's anatomy, with pollen tube entering it.

After a few seconds this panel turned to show a second stage of nuclear change, then a third, and finally an ovule transformed into a seed with its developed and resting embryonic plant. Lights of course then went off and the exhibit returned to its original state. Surrounding this exhibit were various panels and models of flower and seed types with various prepared specimens on a narrow counter below the main panel.

The second Botany unit dealt with photosynthesis. It consisted of four panels, representing four stages in enlargement of a section of a leaf of the corn plant, ending with a huge chloroplastid in bas-relief. The two center panels were mechanized, the first of these showing a greatly enlarged leaf section under a greatly enlarged hand lens. Cells were two or more inches in length and were cut away to permit various pith balls simulating oxygen, carbon dioxide, and water vapor to move in and out of the stomata and move inside the leaf space. I had constructed this exhibit originally to run under compressed air but at Buffalo it had been found necessary to mount many of the simulated molecules on threads, so that they merely quivered in front of a fan, but did not dash madly about as when the exhibit was first made.

A cell of the leaf was then enlarged to two feet in height for the second mechanized panel. Here, by moving tapes, with punched holes and colored back lights, streams of water, oxygen, carbon dioxide, and manufactured food could be shown moving into and out of the cell at the sites of chloroplastids, in a daytime and nighttime sequence. Thus it was possible to demonstrate that plants breathe as we do, and that they breathe all the time, but only make food when there is sufficient light.

The third Botany unit showed the circulation of fluids in the bast and xylem of a trunk or stem, with colored liquid moving in glass tubes in a plaster model trunk. Stem uses were also illustrated on panels.

The fourth unit was built for us by the Buffalo Museum and sent on with the ones we rented from them. It showed by moving lights the action of the root hairs of a root tip, picking up water containing dissolved minerals and passing it up into the root.

The next unit was highly spectacular. Here in a space rising from the floor to a height of fourteen feet we presented two groups of

tomato plants, one group grown in perfect soil, the other in a nutrient solution which was constantly aerated. The plants, when moved in, were ten feet or more in height, supported on giant trellises. They were in bloom and bore green and ripe tomatoes. They continued to grow there throughout the fair, through the energy of artifical light, with one interruption caused by an attack of tobacco mosaic.

When planning this exhibit I had felt that I would be forced to use Mazda light, with filters and exhaust fans to remove heat. Hearing of the new fluorescent lights I persuaded the General Electric Company to allow me to try them in growing plants. The results were spectacular and highly successful. We furnished the light energy for our indoor plants by building ladders of these new, almost cold, lights in their 24-inch tubes. Plants could touch them without harm and by combining tubes colored daylight, white, pink, and blue, we achieved the nearest thing to sunlight that plants have yet used. For the growing of plants these new lights proved eighteen times as effective as Mazda lights, with no heat problem to be controlled. As an exhibit the plants and their lights were highly effective.

Following them we showed a historical review of early botanical explorers of California, with paintings depicting them and with glass mounts showing flowers first collected by each explorer.

A display of desert plants and a comparison of the similarity of evolution of the Euphorbiaceae and the Cactaceae in different continents touched on evolution and adaptation.

Then came a display of redwood fossils with a map contrasting the original world distribution of redwoods with their present restricted range, followed by a concluding exhibit on the molecular structure of cellulose and a protein, giving a foundation for the cell structure and heredity studies that followed.

As the major isolated exhibit in a great circle near the rest of Botany we displayed twelve units devoted to the demonstration of the value of various mineral elements in the growth of young tomato plants. Potassium, calcium, iron, etc., were treated separately, showing the visitor in each case living plants grown with a normal amount of the element, with a slight deficiency, and with practically complete deficiency. Here all growth was in solution and all light again came from our new fluorescents.

A final botanical touch was a frieze of giant painted photographs of typical plant associations or community areas of California, made up from black and white enlargements, with a color photo guide for coloring, taken at the same time and spot as the black and white.

Naturally I cannot take equal time to describe the entire display and will only mention a few others. In Paleontology, the major feature

was a group of six large model-group restorations of ancient animals of the West, made to 1/6th life size. Each represented a scene somewhere in the West ranging from hundreds of thousands to hundreds of millions of years ago.

In Anthropology we made a great map showing the continents and the Pacific Ocean. On this map we traced the major migrations of seven races of men: Neanderthal, white, black, early Mongolian, yellow, Australian and Polynesian. The map was illustrated with over two hundred colored photographs of individuals of these races or of their restorations. When the visitor pushed the right button the origin and route of these migrations were slowly unfolded as picture after picture was lighted and came into view. When the exhibit was at rest, only the map itself and the colored lines marking routes could be seen.

In Zoology the feature was the microprojection of living animals on six large screens in a darkened room that was also soundproofed. Along with this unit, interesting features were the demonstration of recent work on the rabbit egg by Dr. Gregory Pincus and the exhibits of living insects including termites, honeybees, and various plant pests with their control parasites.

In Oceanography I built an ocean, reached by going upstairs, so that in a darkened chamber the visitor could imagine himself beneath the surface of the sea. On a curving, seventy-foot wall, twenty feet high, I scaled off the ocean colors from surface down, representing 400 feet to the foot. In this wall transparent colored pictures of various fishes were shown at their proper depths. Here, too, a sonic sounder continually sent its echo to the bottom and back to the ship's microphones. Curved sound-wave segments were simulated by segments of red lucite, which lighted in proper sequence on their way to the bottom and back.

Medicine presented a March of Life. Here highlights of the University of California's School of Medicine were shown as samples of medical achievement in various age groups. The visitor learned of vitamins, human embryology, allergies, calcium deficiency, proper elementary school medical facilities, thyroid surgery, the differential growth rates of young boys and young girls, the treatment of arthritis, the dangers resulting from obesity, the lengthening of human life through the efforts of medical science, and the hazards of disease that Man may encounter as he associates with his friends, the animals.

A phonograph record in a Clock of the Ages told of the earth's history, as lantern slides presented the changing world epochs and the minutes and seconds of the clock's hands illustrated thousands and millions of years of time.

In conclusion I should mention only one of a considerable series of exhibits in Heredity. This represented the application of principles of Heredity to Man and was illustrated by ninety-five, twelve-inch baby dolls, of proper sex, hair color and eye color. Taking dark hair as a simple dominant to light hair, and brown eyes as a simple dominant to blue eyes, I made it possible for the visitor to select a wife for one of the man dolls, a male dihybrid from a cross of a pure dominant male and a pure recessive female. The four possible wives were phenotypes of dark hair and brown eyes, dark hair and blue eyes, light hair and brown eyes, and light hair and blue eyes. When the push-button, corresponding in color with the dress of the bride selected, was touched, they disappeared, the selected bride appeared with the husband, both in wedding attire, then a suitable row of children appeared, to show the ratios possible from every possible genotype of the selected mother.

It was made clear that with the blue-eyed, light-haired mother a backcross of the hybrid father was made and children of both sexes in equal numbers of the four phenotypes could be expected. But with the blue-eyed, brown-haired mother or the dark-eyed, light-haired mother, two types of women had to be considered in each case, and hence two different sets of children were shown in each case.

When the dark-haired, dark-eyed mother was selected, she could be one of four genotypes, including the dihybrid type of her husband. Forty dolls showed the four possible family combinations of this cross.

In all, the exhibit at California presented a large number of contributions by faculties and departments of the university. Many of these contributions thus became understandable to the public, perhaps for the first time. It can safely be said that this method of scientific presentation by exhibits, while expensive, represents one of the most effective means of bringing scientific contributions and scientific principles to public attention.

SOURCE MATERIALS FOR FLORIDA ABORIGINAL ARTIFACTS

J. Clarence Simpson
Florida Geological Survey

Stone artifacts found in peninsular Florida are of two general types, those formed by pecking, grinding and rubbing, and those hammered and chipped by pressure. The first type is usually made of fine, close-grained, igneous and metamorphic rocks imported from mountainous regions of Alabama, Georgia and South Carolina, where the nearest outcrops of such rocks occur. The second type is made of stone and flint indigenous to the Florida peninsula. Contrary to the impression entertained by many archeologists, both trained and amateur, there is an abundance of rock in this part of the state suitable for the manufacture of stone implements.

Limestone exposures of Eocene, Oligocene and Miocene rocks are common along the west coast and central part of the peninsula. Though the Eocene rocks are commonly a soft, pliable, cream to white limestone, in places they contain large concretionary boulders of chert. Where rocks of this age had been eroded the concretions remained as residual boulders and furnished raw material to the early Floridan Indians. Further to the east and south rocks from the Tampa and Hawthorn formations of Miocene age furnish large amounts of silicified fossil material and, in Hillsborough County and other places in the north-central part of the state, are large fossil coral reefs that have become extensively chalcedonized. These materials were widely used in the manufacture of the chipped stone artifacts.

Localities where siliceous rocks occurred were extensively used with preference for damp areas, since flint and chert chip more easily when wet. Such quarries existed in Pinellas, Jefferson, Alachua, and Hillsborough counties. The quarries in Hillsborough county were the most extensive due possibly to the twofold reason that the material was of high quality and because, since it is the southernmost occurrence of such rocks, it was the source of supply for tribes over considerable area to the south. These quarries are in the area around Lake Thonotosassa, a Muscogean word combination meaning "Flint Place." One of the largest of these quarries, comprising 60 or 70 acres, is located on the Ratliffe property in the southeast quarter of section 5 and southeast quarter of section 6, T 28 S, R 30 E. This is a slightly elevated locality in a generally swampy area, where the rock is covered by a thin coating of muck and soil, and was quarried by digging shallow trenches and pits. Evidence remains that fires were built to help break the stones into rough shapes after which they

were further worked by hammering into blanks that were carried away to be finished. There is no evidence that any implements were finished here but the extent of operations is shown by the abundance of broken spalls and rejects found a half mile in all directions. This flint material has been so plentiful that individuals have found it profitable to recover it for use as concrete aggregate.

Smooth stone artifacts usually consist of celts, pendants, ceremonial stones, polished axes, mortars and pestles but the last three are seldom found in Florida. The grooved axe was never in general use and the mortars and pestles were usually made of wood. These smooth stone artifacts were usually made of materials brought from the mountainous regions to the north.

Other types of polished articles found are of materials indigenous to Florida so it may not be argued that the Floridan aborigines had to use the imported stones. In the area of the Itchatucknee, Santa Fe and Suwannee rivers are many polished stone club heads made of badly weathered limestone and better preserved specimens made of iron sandstone. A few were made of deer antlers and in association with them numerous highly mineralized bone awls, fish hooks, and ornaments have been found. In this material the writer found three awls made of ivory whose grain indicates that it must have come from a mastodon or elephant. Fossil ivory found in Florida is far too fragile for use in making rugged instruments such as an awl and the inference is that the makers of such implements were contemporary with Pleistocene animals and antedate by many years the tribes that enjoyed commercial intercourse with tribes further to the north.

The everyday cutting and piercing instruments, consisting of arrowheads, spearheads, hoes, scrapers, knives, saws, chipped celts and hammer stones, were made of stone found in peninsular Florida. In a check of more than three thousand specimens the writer found only one exception to this, a six inch spearhead of milky quartz that has been found on the edge of Payne's Prairie. Chert was the most commonly used material followed closely by chalcedony and jasper. These last display beautiful colorations from reds through brown, yellows, and whites to blue, sometimes with several colors showing in the same implement.[1]

The native materials of the peninsula are all of siliceous rock ranging from flint and chert to sard and opal, the last occurring in Hillsborough County, chiefly as pseudomorphs after coral. As might be expected, chert was the most commonly used material.

[1]In west Florida, however, many chipped artifacts are made of imported material as native flint is very scarce in that area. In fact, it is almost entirely absent west of Holmes County.

The trade routes of the pre-Columbian Indians of Florida were obviously the same as those in historic times, a western route through the watershed of the Chattahoochee and Flint rivers, and an eastern route following the route of the present inland waterway, within the barrier islands and through St. Johns drainage area. Further south, Lake Okeechobee and the wide expanse of the Everglades furnished an open road for the Indian with his canoe. Village sites and mounds along these routes have been found richer in trade articles than those in the interior sections remote from the water routes. This has given rise to several postulates, one that the interior sites were only temporary locations for hunting bases and so did not represent the culture of the permanent ones along the trade routes, or that these interior sites were in many cases the homes of defeated bands refuged there and having little intercourse with the coast tribes.

UNSCRAMBLING THE VITAMINS

L. L. Rusoff
University of Florida

At present there is some confusion in the identification and the status of the vitamins. A few years ago six vitamins were recognized officially as chemical entities, namely: Vitamins A, B_1, C, D, E, and B_2 or G. To date, four more vitamins can be added to the list, namely: Vitamin K, Pyridoxine (vitamin B_6), Nicotine Acid (pellagra-preventive vitamin) and Pantothenic Acid (rat anti-acrodynia factor). Besides these official vitamins many additional vitamin factors have been claimed by nutritional investigators of the United States and Europe. This increase in number has been due to the study of the vitamin requirements of different species of animals and to the investigation of the chemical and physical properties of old and new vitamins.

During early experimental investigations with these vital factors, letters of the alphabet were used to designate new vitamins because their chemical identities were unknown at that time. Today chemical or specific names are used in place of letters of the alphabet whenever the constitution of a vitamin has been determined. However, there are many new vitamins that have been discovered for which chemical identities are obscure for the present and letters of the alphabet are still used.

In this paper an attempt will be made to present the status of the vitamins and particularly to point out the recent findings.

I. FAT SOLUBLE GROUP

VITAMIN A— ($C_{20}H_{29}OH$) the anti-infective vitamin, the anti-xerophthalmic vitamin, the growth-promoting vitamin.

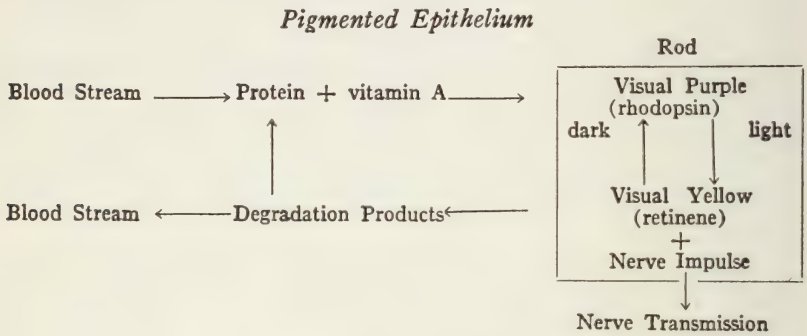
The chief role of vitamin A is to keep the mucous membranes of the body in a healthy condition. These constitute the first barrier against invading bacteria, thus aiding the body against infections in general. However, vitamin A is not specific against colds, influenza and such infections.

A deficiency of vitamin A results in xerophthalmia, a characteristic eye disease.

The condition of night blindness (defective vision in dim light) has been attributed to vitamin A deficiency. Vitamin A is combined with a protein in the rods of the retina of the eye forming visual purple (rhodopsin)[1], a photosensitive pigment, which serves to transfer

[1]G. Wald and A. B. Clark, "Sensory Adaptation and Chemistry of Retinal Rods," *Amer. Jour. Physiol., Vol.* 116 (1936), pp. 157-158.

the energy of dim light into nerve impulses. The pigment is bleached in bright light and is regenerated in the dark. When the body stores of vitamin A are depleted visual purple is not regenerated and vision in dim light is impaired. The following diagram illustrates the relationship of vitamin A and the perception of vision[2].



The increase in the number of automobile accidents at dusk has been associated with the condition of night blindness. Vitamin A is specific for night blindness if this condition is of dietary origin, and therefore, the ingestion of vitamin A by drivers of automobiles who are suffering from night blindness will diminish the chance of accident from driving at night.

Vitamin A is also necessary for growth, reproduction and lactation in higher animals.

The probable daily requirement is 4500 International Units for children and 6000 International Units for adults. One International Unit is equal to the growth-promoting activity of 0.6 micrograms (0.0006 milligrams) of beta carotene.

VITAMIN A_2 — Vitamin A has been reported to occur naturally in more than one form.[3,4,5,6] Vitamin A_2 seems to be the principal form of vitamin A of fresh water fish. It has a spectral band distinguish-

[2]S. Hecht, "Rods, Cones and the Chemical Basis of Vision," *physiol. Reviews*, Vol. 17 (1937), pp. 239-290.

[3]A. E. Gillam, I. M. Heilbron, W. E. Jones and E. Lederer, "On the Occurrence and Constitution of 693 mu Chromogen (Vitamin A_2?) of Fish Liver Oils," *Biochem. Jour.*, Vol. 32 (1938), pp. 405-416.

[4]E. Lederer and F. H. Rathmann, "Sur les vitamines, A_1 et A_2," *Comptes Rendus Acad. Sci.*, Vol. 206 (1938), pp. 781-783.

[5]J. A. Lovern, R. A. Morton and J. Ireland, "The Distribution of Vitamins A and A_2," *Biochem. Jour.*, Vol. 33 (1939), pp. 325-329.

[6]J. A. Lovern and R. A. Morton, "The Distribution of Vitamins A and A_2," *Biochem. Jour.*, Vol. 33 (1939), pp. 330-337.

able from vitamin A and it has been suggested that vitamin A has an additional — CH=CH— group in the molecule.

PROVITAMINS A — Alpha, Beta, Gamma Carotenes and Crypto-
($C_{40}H_{56}$-beta cartoene) xanthin.

These four substances are yellow-red plant pigments which occur in most green and yellow-green tissues. They are precursors or parent substances of vitamin A and are converted to vitamin A in the animal body.[7,8]

Thus we should speak of the vitamin A activity or provitamin A content of plant tissues and not their vitamin A content.

VITAMIN D— the anti-rachitic vitamin, the bone-building vitamin, the sunshine vitamin.
($C_{27}H_{43}OH$)-(Calciferol)

Vitamin D along with calcium and phosphorus is required by the body to build strong and healthy bones and sound teeth in the young, and to maintain these in the adult. It prevents and cures rickets.

Vitamin D is produced when foods and animal bodies are exposed to the ultra-violet light of the sunshine or of artificial light. This is brought about by the irradiation of provitamin D which changes to vitamin D. Thus irradiated foods are now available which are protective against rickets.

At least eleven forms of vitamin D of different chemical make-up have been shown to exist.[9] Three forms of vitamin D are definitely recognized:

Vitamin D_2 or calciferol—irradiated or activated ergosterol which occurs in many irradiated foods and may occur in nature.

Vitamin D_3 — activated 7 dehydrocholesterol. This form has been shown to be the chief form of the vitamin found in certain fish oils.

Vitamin D_4 — activated 22 dihydrocalciferol. This form is found in irradiated foods or may occur in nature.

Since vitamin D is not found in appreciable quantities in so many of our foods, the tendency to fortify these foods with vitamin D

[7]T. Moore, "Vitamin A and Carotene. V. The Absence of the Liver Oil Vitamin from Carotene. VI. The Conversion of Carotene to Vitamin A in Vivo," *Biochem. Jour.*, Vol. 24 (1930), pp. 696-702.

[8]T. Moore, "The Distribution of Vitamin A and Carotene in the Body of the Rat," *Biochem. Jour.*, Vol. 25 (1931), pp. 275-286.

[9]C. I. Reed, H. C. Struck and I. E. Steck, *Vitamin D* (Chicago: The University of Chicago Press, 1939).

is in vogue. According to Dr. E. M. Nelson [10], of the Food and Drug Administration, Washington, D. C., "of the common foods fortified with vitamin D, only milk needs to receive serious consideration. The remainder are all too frequently transients and usually emblazoned with statements of these alleged virtues in a manner that cannot escape notice."

In Florida, "Land of Sunshine" and especially in St. Petersburg, plenty of ultra-violet light is available the year round to insure sufficient vitamin D for good strong bones and healthy sound teeth provided we take advantage of this wonderful sunshine.

The probable daily requirement for children and adults is 400 to 500 International Units. One International Unit is equivalent to the activity of 0.025 micrograms (0.000025 milligrams) of calciferol.

For mammals one unit of vitamin D_2 is equal to one unit of vitamin D_3. A vitamin D activity of 50 rat units in irradiated ergosterol is equivalent to only 1 rat unit of vitamin D activity in cod liver oil when these substances are used as a source of vitamin D for chicks. An explanation advanced is that vitamin D_2 is less effective than vitamin D_3 in this species.

ALPHA TOCOPHEROL—vitamin E, the anti-sterility vitamin, the ($C_{29}H_{50}O_2$) reproductive vitamin.

At least 3 substances have been shown to possess vitamin E activity, these being alpha, beta and gamma tocopherols. Alpha tocopherol is the most potent.

Alpha tocopherol protects against sterility. It is necessary for reproduction and growth in certain species and probably humans. Since vitamin E is very common in ordinary foods it is hardly possible that human sterility results from its deficiency.

It has been reported that some relationship exists between vitamin E and muscle weakness[11]. Alpha tocopherol was synthesized a few years ago[12, 13].

[10]E. M. Nelson, "The Determination and Sources of Vitamin D," *Jour. Amer. Med. Assoc.*, Vol. 111 (1938), pp. 528-530.

[11]M. Goettsch and J. Ritzmann, "The Preventive Effect of Wheat Germ Oils and of Alpha Tocopherol in Nutritional Muscular Dystrophy of Young Rats," *Jour. Nutrition*, Vol. 17 (1939), pp. 371-381.

[12]L. I. Smith, H. E. Ungnade and W. W. Prichard, "The Chemistry of Vitamin E. I. Structure and Synthesis of Alpha Tocopherol," *Science*, Vol. 88 (1938), pp. 37-38.

[13]P. Karrer, H. Fritsche, B. H. Ringier and H. Salomon, "Alpha Tocopherol," *Helvetica Chimica Acta*, Vol. 21 (1938), pp. 520 ff.

VITAMIN K— ($C_{17}H_7O_2$-R) (phytol) the anti-hemorrhagic vitamin, coagulations vitamin. This vitamin was discovered when chicks were used as experimental animals.[14,15]

Vitamin K is essential to the formation of prothrombin, the substance which functions in the clotting of blood. It was isolated and synthesized last year[16, 17].

There are two forms of vitamin K[18]:

Vitamin K_1—the non-crystalline factor from alfalfa and

Vitamin K_2—the crystalline vitamin from putrefied fish meal.

Recently vitamin K has been used clinically as a pre-operative and post-operative measure to prevent risk of bleeding in patients with obstructive jaundice.

II. WATER SOLUBLE GROUP

ASCORBIC ACID—Cevitamic acid, vitamin C, the anti-scorbutic ($C_6H_8O_6$) vitamin, the anti-scurvy vitamin.

Ascorbic acid is required for the correction and prevention of scurvy. It is necessary for the formation of the substances which holds cells together. Ascorbic acid keeps the teeth and gums, and the blood vessels in a healthy condition. It prevents hemorrhages in the skin and other tissues and keeps the bones from becoming porous and fragile.

Humans, monkeys and guinea pigs require ascorbic acid in their diets while ruminants, poultry and rats do not require it in their rations, apparently being able to synthesize this factor.

The probable daily requirement for children and adults is 1500 to 1800 International Units. One International Unit is equivalent to the activity of 0.05 milligrams of crystalline ascorbic acid.

VITAMIN B COMPLEX. Approximately 10 or 15 factors have been separated and isolated from the old vitamin B. Of these only four factors—Thiamin (vitamin B_1), Riboflavin (vitamin G), Nicotinic Acid (pellagra-preventive factor) and Pyridoxine (vitamin B_6) have been shown to be necessary for human nutrition.

[14]H. Dam, "The Anti-Haemorrhagic Vitamin of the Chick," *Biochem. Jour.* Vol. 29 (1935), pp. 1273-1285.

[15]H. J. Almquist and E. L. R. Stokstad, "Hemorrhagic Chick Disease of Dietary Origin," *Jour. Biol. Chem.*, Vol. 111 (1935), pp. 105-113.

[16]D. W. MacCorquodale, "Constitution and Synthesis of Vitamin K," *Jour. Biol. Chem.*, Vol. 131 (1939), pp. 357-370.

[17]L. F. Fieser, "Synthesis of 2 methyl—3 phytyl—1, 4 naphthoquinone," *Jour. Amer. Chem. Soc.*, Vol. 61 (1939), pp. 2559-2561.

[18]R. W. McKee, S. B. Binkley, D. W. MacCorquodale, S. A. Thayer and E. A. Doisy, "The Isolation of Vitamins K_1 and K_2," *Jour. Amer. Chem. Soc.* Vol. 61 (1939), p. 295. (Letter to Editor).

1. *THIAMIN*— ($C_{12}H_{17}N_4OS$) Aneurin, vitamin B_1, the anti-neuritic vitamin, the anti-beriberi vitamin, the apetite-stimulating vitamin.

Thiamin is required to keep the nerves in a healthy condition and is of value in preventing and curing beriberi in man and polyneuritis in animals. It is essential for good appetite, normal digestive functions, reproduction, lactation and growth.

It has been reported that thiamin enters into the composition of a coenzyme, Cocarboxylase, which is necessary for the breakdown of pyruvic acid, one of the steps in the oxidation of carbohydrate by the cell[19, 20, 21].

Micro-organisms in the digestive tract of ruminants are able to synthesize thiamin and thus this species does not require this vitamin in its feed.

The probable daily requirement for children or adults is 400 to 500 International Units. One International Unit is equivalent to the activity of 3.0 micrograms (0.003 milligrams) of crystalline thiamin.

Thiamin has been reported to play a conspicuous role as a factor for growth of plants, particularly in stimulating root formation in cuttings[22].

2. *RIBOFLAVIN*—vitamin G, the growth-promoting vitamin. ($C_{17}H_{20}N_4O_6$)

Riboflavin is a greenish yellow fluorescent pigment which is present in the whey of milk, in liver, eggs and many plants. Riboflavin is necessary for growth. It has been reported that riboflavin prevents lesions of the skin and eyes in humans, prevents loss of fur and dermatitis in rats, and nerve degeneration in dogs and chicks.

Riboflavin also enters into the composition of an enzyme by combining with special proteins to form Warburg's "Yellow Oxidation Ferment."[23]

This enzyme specific catalyzes certain oxidation-reduction systems in living tissues.

[19]K. Lohmann and P. Schuster, "Über die Co-carboxylase," *Naturwissenschaften,* Vol. 25 (1837), pp. 25-26.

[20]K. Lohmann and P. Schuster, "Untersuchungen über die Co-carboxylase," *Biochem. Zeitung,* Vol. 294 (1937), pp. 188-214.

[21]I. Banga, S. Ochoa and R. H. Peters, "The Active Form of Vitamin B_1 and the Role of C_4 Dicarboxylic Acids," *Biochem. Jour.,* Vol. 33, (1939), pp. 1109-1121.

[22]F. W. Went, J. Bonner and G. C. Warner, "Aneurin and the Rooting of Cuttings," *Science,* Vol. 87 (1938), pp. 170-171.

[23]H. Theorell, "Das gelbe Oxydationsferment," *Biochem. Zeitung,* Vol. 278 (1935), pp. 263-290.

The probable daily requirement is 1 to 2 milligrams of crystalline riboflavin per day. No standard unit has been designated.

3. *NICOTINIC ACID* and *NICOTINIC ACID AMIDE* — vitamin
($C_6H_5O_2N$) P-P, the anti-pellagric factor.

Nicotinic acid has been known since 1867 but its nutritional importance was not discovered until a few years ago[24]. Nicotinic acid is required in the nutrition of dogs, pigs and humans. It is believed to be the chief factor in the prevention and alleviation of canine black tongue and of human pellagra, yet in some instances other members of the vitamin B complex must be present and in chronic cases even these factors do not cause any response because secondary complications have set in.

Nicotinic acid has been reported to be part of a co-enzyme, Cozymase, which is an indispensable agent in biological oxidation-reduction systems concerned with carbohydrate metabolism[25].

The probable daily requirement is 25 milligrams per day. No standard unit has been designated.

4. *PYRIDOXINE*—adermin, vitamin B_6, factor 1, the anti-acro-
($C_8H_{11}O_3N$) dynia factor, the rat anti-dermatitis vitamin.

Pyridoxine is required by all animals. It has been reported to prevent a characteristic dermatitis in rats and swine, to be required for growth by chicks, and to be needed for the alleviation of some of the symptoms of human pellagra.

The chemical structure of pyridoxine was elucidated in 1939[26], and this substance was synthesized the same year [27].

The daily requirement is not known.

5. *PANTOTHENIC ACID*—the chick filtrate factor, the anti-grey
($C_9H_{17}O_5N$) hair factor, the chick anti-dermatosis factor.

Pantothenic acid is required by poultry and probably by all other animals. It protects against a pellagra-like syndrome in chicks.

[24]C. A. Elvehjem, R. J. Madden, S. M. Strong and D. W. Woolley, "Relation of Nicotinic Acid and Nicotinic Acid Amide to Canine Black Tongue," *Jour. Amer. Chem. Soc.,* Vol. 59 (1937), pp. 1767-1768.

[25]H. Von Euler, A. Albers and F. Schlenk, "Chemische Untersuchungen an hochgereinigter Co-zymase," *Zeitschrift Physiol. Chemie,* Vol. 239 (1936), pp. 113-126.

[27]S. A. Harris and K. Folkers, "Synthesis of Vitamin B_6," *Jour. Amer. Chem. Jour. Amer. Chem. Soc.,* Vol. 61 (1939), pp. 1242-1244.

[27]S. A. Harris and K. Folkers, "Synthesis of Vitamin B_6", *Jour Amer. Chem. Soc.,* Vol. 61 (1939), pp. 3307-3310.

Just a few months ago (March, 1940) the chemical structure of pantothenic acid was determined and its synthesis achieved.[28,29]

The daily requirement is not known.

6. *OTHER VITAMIN B COMPLEX FACTORS*—(Not Well Known)

Name	*Experimental Animal*	*Ascribed Functions*
Vitamin B_3[30] — thermostable factor in yeast	Pigeon	Weight Gain
Vitamin B_4[31] — heat and alkali labile factor in yeast	Rat	Weight Maintenance Anti-paralysis
Vitamin B_5[32] — heat and alkali stable factor in yeast and whole wheat	Pigeon	Weight Gain
Vitamin Bc[33]	Chicks	Prevents Anemia
Vitamin Bp[34]	Chicks	Anti-Perosis
Vitamin Bx[35]	Silver Fox	Prevents Graying of Fur
Vitamin Bw[36]	Rat	Growth
Vitamin H — (Anti-Egg White Factor)[37,38,39]	Rat	Prevents Egg White njury

[28]R. J. Williams and R. T. Major, "The Structure of Pantothentic Acid," *Science, Vol.* 91 (1940), p. 246.

[29]E. T. Stiller, S. A. Harris, J. Finkelstein, J. C. Keresztesy and K. Folkers, "Pantothenic Acid. VIII. The Total Synthesis of Pure Pantothenic Acid," *Jour. Amer. Chem. Soc.,* Vol. 62 (1940), pp. 1785-1790.

[30]C. W. Carter and J. R. O'Brien, "Maintenance Nutrition in the pigeon. The Effect of Vitamin B_1," *Biochem. Jour.,* Vol. 31 (1937), pp. 2264-2269.

[31]O. L. Kline, C. A. Elvehjem and E. B. Hart, "Further Evidence for the Existence of Vitamin B_4," *Biochem. Jour.,* Vol. 30 (1936), pp. 780-784.

[32]C. W. Carter and J. R. O'Brien, "Maintenance Nutrition in the Pigeon. Vitamin B_5," *Biochem. Jour.,* Vol. 31 (1937), pp. 2270-2273.

[33]A. G. Hogan and E. M. Parrott, "Anemia in Chicks Caused by a Vitamin Deficiency," *Jour. Biol. Chem.,* Vol. 132 (1940), pp. 507-517.

[34]A. G. Hogan, L. R. Richardson and H. Patrick, "Relation of Perosis to Unrecognized Vitamins," *Jour. Nutrition,* Vol. 18 (1940), Supplement 1, p. 14.

[35]G. Lunde and H. Kringstad, "Bedarf des Fuches an dem Anti-Grau-Haarfaktor Vitamin Bx," *Naturwissenschaften,* Vol. 27 (1939), p. 755.

[36]H. Kringstad and G. Lunde, "Untersuchungen über den Filtratwachstumsfaktor Bw," *Zeitschr. physiol. Chem.,* Vol. 261 (1939), pp. 110-124.

[37]P. Gyorgy, "Attempts to Isolate the Anti-Egg White Injury Factor (Vitamin H)," *Proc. Amer. Soc. Biol. Chem.* (1937), pp. XLIII-XLIV.

[38]Identical with Biotin, part of the B complex required by the chick and rat to prevent skin disease.

[39]P. Gyorgy, D. B. Melville, D. Burk and V. duVigneaud, "The Possible Identity of Vitamin H with Biotin and Co-enzyme R," *Science,* Vol. 91 (1940), pp. 243-245.

Name	*Experimental Animal*	*Ascribed Functions*
Factor R — heat labile[40]	Chicks	Growth
Factor S — heat stable		
Factor U[41]	Chicks	Growth
Factor W[42] — thermo labile factor from liver extract	Rat	Growth
Factor Y[43]	Rat	Growth
Anti-Gizzard Erosion Factor[44,45]	Chick	Prevents Gizzard Erosion
Anti-Gray Hair Factor[46,47,48]	Rat	Prevents Graying and Fading of Hair in Black, Gray and Hooded Rats
Anti-Alopecia Factor[49]	Mouse	Growth and Maintenance of Hair
Chlorine[50]	Rat	Growth - Prevents Development of Fatty Liver

[40]A. E. Schumacher, G. F. Heuser and L. S. Norris, "The Complex Nature of the Alcohol Precipitate Factor Required by the Chick," *Jour. Biol. Chem.*, Vol. 135 (1940), pp. 313-320.

[41]E. L. Stokstad and P. D. V. Manning, "Evidence of a New Growth Factor Required by Chicks," *Jour. Biol. Chem.*, Vol. 125 (1938), pp. 687-696.

[42]D. V. Frost and C. A. Elvenjem, "Further Studies on Factor W," *Jour. Biol. Chem.*, Vol. 121 (1937), pp. 255-273.

[43]H. Chick and A. M. Copping, "The Composite Nature of the Water-Soluble Vitamin B_1. III. Dietary Factors in Addition to the Anti-Neuritic Vitamin B_1 and the Anti-Dermatitis Vitamin B_2," *Biochem. Jour.*, Vol. 24 (1930), pp. 1764-1779.

[44]H. J. Almquist and E. L. R. Stokstad, "A Nutritional Deficiency Causing Gizzard Erosion in Chicks," *Nature*, Vol. 137 (1936), p. 581.

[45]H. R. Bird, O. L. Kline, C. A. Elvehjem, E. B. Hart and J. G. Halpin, "Distribution and Properties of the Anti-Gizzard Factor Required by Chicks," *Jour. Nutrition*, Vol. 12 (1936), pp. 571-582.

[46]A. F. Morgan, B. B. Cook, and H. G. Davidson, "Vitamin B_2 Deficiencies as Affected by Dietary Carbohydrate," *Jour. Nutrition*, Vol. 15 (1938), pp. 27-43.

[47]A. F. Morgan and H. D. Simms, "Greying of Fur and other Disturbances in Several Species due to a Vitamin Deficiency," *Jour. Nutrition*, Vol. 19 (1940), pp. 233-250.

[48]Possibly identical with pantothenic acid.

[49]D. W. Woolley, "A New Dietary Essential for the Mouse," *Jour. Biol. Chem.*, Vol. 136 (1940), pp. 113-118.

[50]C. H. Best and J. H. Ridout, "Choline as a Dietary Factor," *Ann. Rev. Biochem.*, Vol. 8 (1939), pp. 349-370.

Name	*Experimental Animal*	*Ascribed Functions*
Maintenance and Growth Factor[51]	Chicks	Growth
Chrondroitin Sulfuric Acid[52]	Chicks	Growth
Cartilage Growth Factor[53]	Chicks	Growth

It is probable that many of these less known vitamins are either identical or else closely related.

III. OTHER VITAMIN FACTORS (Not Well Known)

Name	*Experimental Animal*	*Ascribed Functions*
Essential Fatty Acids[54] (VitaminF)[55]	Rat	Prevents a Dermatitis Due to a Fat Deficiency
Vitamin H[56] — heat labile factor from fresh meat	Trout	Growth
Factor J[57]	Guinea Pig	Prevents Pneumonia
Vitamin L_1[58] — from beef liver freed of B complex	Rat	Reproduction
Vitamin L_2[58] — from Baker's yeast freed of B complex	Mice	Lactation
Vitamin M[59] — from yeast and liver extract	Monkey	Prevents Nutritional Cytopenia
Vitamin P — (Citrin)[60]	Guinea Pig	Prevents Capillary Fragility

[51]R. Van der Hoorn, H. D. Branion and W. R. Graham, Jr., "Studies in the Nutrition of the Chick. 3. A Maintenance Factor Present in Wheat Germ and the Effect of the Addition of a Small Amount of MnO_2 to the Diet," *Poultry Sci.*, Vol. 17 (1938), pp. 185-192.

[52]H. E. Robinson, R. E. Gray, F. F. Chesley and L. A. Crandall, "Chondroitin Sulfuric Acid as a Growth Factor," *Jour. Nutrition*, Vol. 17 (1939), pp. 227-233.

[53]D. M. Hegsted, J. J. Oleson, C. A. Elvehjem and E. B. Hart, "The Cartilage Growth Factor and Vitamin B_6 in the Nutrition of Chicks," *Jour. Biol. Chem.*, Vol. 130 (1939), pp. 423-424.

[54]G. O. Burr, M. M. Burr and E. S. Miller, III, "On the Fatty Acids Essential in Nutrition," *Jour. Biol. Chem.*, Vol. 97 (1932), pp. 1-9.

[55]Vitamin F has been dropped by the American Society of Biological Chemists.

[56]C. M. McCay, "The Biochemistry of Fish," *Ann. Rev. Biochem.*, Vol. 6 (1937), pp. 445-468.

[57]H. von Euler, H. Söder and M. Malmberg, "The Action of Nutrient Factor J on the Development of Pneumonia in Guinea Pigs," *Zeitschreift f. Hygiene u. Infectionskr.*, Vol. 116 (1935), p. 672. (from Chem. Abstracts, Vol. 29, p. 5890).

[58]W. Nakahara, F. Inuki and S. Cgami, "Vitamin L and Filtrate Factor," *Science*, Vol. 91 (1940), p. 431.

[59]W. C. Langston, W. J. Darby, C. F. Shukers and P. L. Day, "Nutritional Cytopenia (Vitamin M) Deficiency in the Monkey," *Jour. Exp. Med.*, Vol. 68 (1938), pp. 923-940.

Name	*Experimental Animal*	*Ascribed Functions*
Chick Anti-Encephalomalacia Factor[61]	Chick	Prevents Lesions of Cerebrum and Cerebellum
"Grass Juice" Factor or Factors[62]	Rat	Growth and Reproduction

This last decade has been called the "vitamin era." Vitamins and vitamin concentrates have been over-emphasized and exaggerated, and the public exploited. It is estimated that during last year, over $100,000,000 were spent for vitamin preparations by the people of the United States.

It is known that foods which are selected and processed have a reduced vitamin content. At present there is a trend to restore vitamins to processed foods because crystalline vitamins are being synthesized in unlimited quantities and at a reasonable price. There is no doubt that vitamized foods will have their place in your diet. However, in order to insure good health and optimum nutrition, a varied diet containing generous amounts of natural foods—milk and milk products, fresh vegetables, fresh fruits, fresh meat and eggs, and plenty of sunshine is advocated.

[60]S. Rusznyâk and A. Szent-Györgyi, "Vitamin-P Flavonols as Vitamins," *Nature,* Vol. 138 (1936), p. 27.

[61]A. M. Pappenheim and M. Goettsch, "A Cerebellar Disorder in Chicks Apparently of Nutritional Origin," *Jour. Exper. Med.,* Vol. 53 (1931), p. 11.

[62]G. O. Kohler, C. A. Elvehjem and E. B. Hart, "Growth-Stimulating Properties of Grass Juice," *Science,* Vol. 83 (1936), p. 445.

A NEW SPECIES OF HAMMERHEAD SHARK OF THE GENUS SPHYRNA

STEWART SPRINGER
Bass Biological Laboratory

My studies of Hammerhead sharks collected from the Gulf of Mexico in the vicinity of Englewood have shown that certain forms referable to the *Sphyrna zygaena* group represent a distinct species. This paper gives a description of the new species and comparisons with other known species of the genus *Sphyrna.*

Genus SPHYRNA Rafinesque

Sphyrna diplana, new species

Sphyrna zygaena Springer, 1939, pp. 31-32, fig. 16.

HOLOTYPE.—A sub-adult male, 1.735 meters in total length, U. S. N. M. 108451, collected off Englewood, Florida, January 24, 1939.

PARATYPES.—A head and two dry jaws, U. S. N. M. nos. 108452, 110296, and 110297.

DESCRIPTION.—A large species (males mature at about 1.8 meters and reach a length of at least 2.5 meters); body strongly compressed; head flattened, hammer-shaped, its front margin between the nasal apertures four-lobed and a deep notch in the front margin before each nasal aperture; a deep groove (deeper than wide) in the front margin of the head originating behind the nasal flap and extending about the length of the adjacent lobe; mouth moderate, well forward in head, a line through its angles extending through or in advance of the posterior edge of the hammer except in some very large individuals; all teeth with smooth cusps, relatively high in the lower jaw, in $\frac{15+1+15}{15+1+15}$ to $\frac{16+2+16}{15+2+15}$ vertical rows, typically in $\frac{16+0+16}{15+1+15}$ rows; teeth of upper jaw narrowly triangular, strongly inclined toward the angles of the jaws, outer margins (toward the angles of the jaws) of the cusps usually convex, inner margins often slightly concave toward the tips; lower teeth narrower, more erect, with convex outer margins and concave inner margins more pronounced; pectoral fins relatively small; first dorsal large, very high; caudal region heavy, tail large; second dorsal low, the posterior lobe produced so that the tip, when lifted upward, will extend for a distance more than twice as great as the height of the fin; denticles small, imbricate, about as broad as long, with 5 to 7 ridges; skin thin; preorbital process of the cranium nearly transverse, with a broad anterior wing, the forward edge of which lies immediately beneath the groove of the front

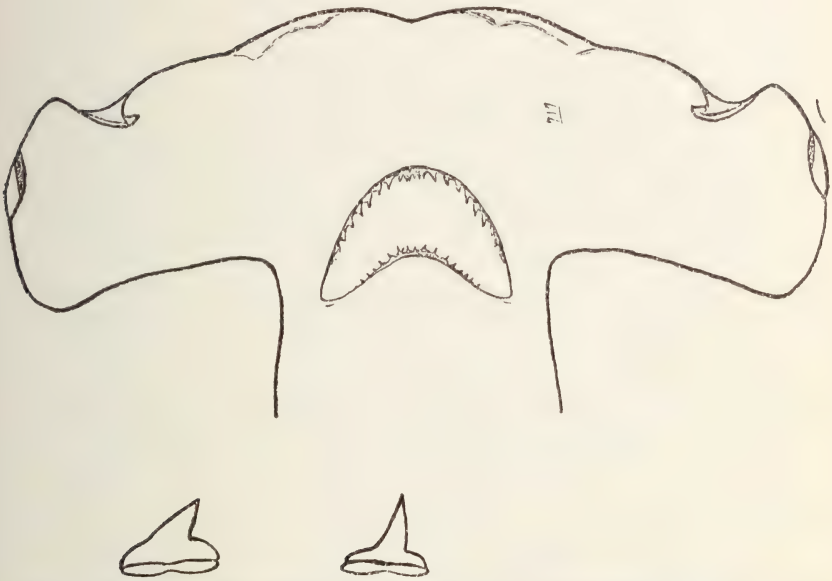


Fig. 1.—*Sphyrna diplana,* lower side of head, and typical teeth from upper (or left), and lower (on right), jaws. Drawn from a 1500 mm male collected at Englewood.

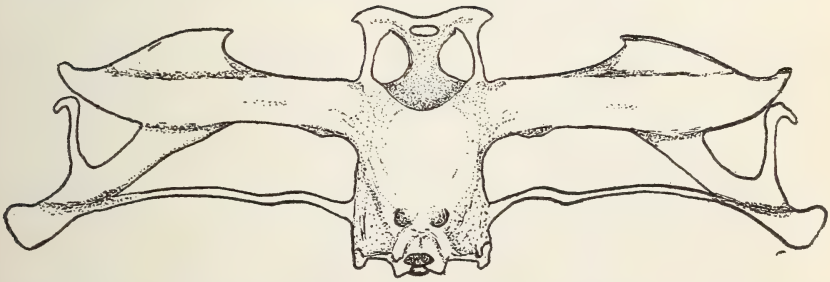


Fig. 2.—*Sphyrna diplana,* dorsal aspect of cranium. Taken from 1500 mm male collected at Englewood.

margin of the head, the wing with an inwardly directed point; rostral cartilage with a median oval hole (present in all of the specimens examined); labial cartilages reduced or wanting; vertebrae about 200 (196 to 204 in seven specimens), about half in the caudal portion after the pit; color light gray, whitish below, the pectorals tipped on their ventral surfaces with black.

COMPARISONS WITH OTHER SPECIES.—Hammerheads of the *zygaena* group, to which this species may be referred, may be distinguished from other hammerheads and shovel-head sharks by the presence of a long posterior lobe on the second dorsal fin and by the presence of a deep groove in the front margin of the head. In this group, I recognize the existence of three valid species in addition to the form described here. They are *Sphyrna zygaena* (Linnaeus), *S. oceanica* (Garman), and *S. lewini* (Griffith). *Sphyrna zygaena* is represented in the material I have seen by specimens from the vicinity of New York harbor; Woods Hole, Massachusetts; Seaside Park, New

Fig. 3.—*Sphyrna zygaena,* dorsal aspect of cranium from 570 mm male collected at Sandy Hook Bay, New York.

Jersey; Livorno, Italy; and Terceira, Azores, all 495 to 635 mm in total length. The species seems ordinarily to be 500 to 550 mm long at birth. I have seen no adult specimens, but Coles (pl. 3, fig. 3)[1] gives a photograph of a female, 11 feet 1 inch (about 3.35 meters) long, taken at Cape Lookout, North Carolina, on July 1 which appears to be *S. zygaena.* At least the photograph shows a specimen with a three lobed head, although Coles states that the front of the head has a notch only faintly indicated. This individual was said to have contained 18 or more young 21¾ (546 mm) to 26½ (673 mm) inches long, a length greater than many of the new born specimens of *zygaena* I have

seen. Coles reported on two large hammerheads. One of them, which he regarded as abnormal, is *Sphyrna tudes*. The specimen which I refer to *S. zygaena* is said by Coles to be normal, but he states that ". . . . . the front of its head was more crescentic in form than usual in the species . . . ." It is evident that Coles thought neither of the specimens were typical of the species most common to the Atlantic coast of the United States, yet his records are about the only detailed ones of adult hammerheads from the United States waters. Radcliffe (pp. 263-265)[2] writing of hammerheads from Beaufort, North Carolina, discussed material which I refer variously to *S. tudes, S. zygaena,* and *S. diplana.* Young specimens of *S. diplana* from the Carolinas, the coasts of Texas, Louisiana, and Mississippi, as well as from both coasts of Florida have been available to me for study. The head of a half

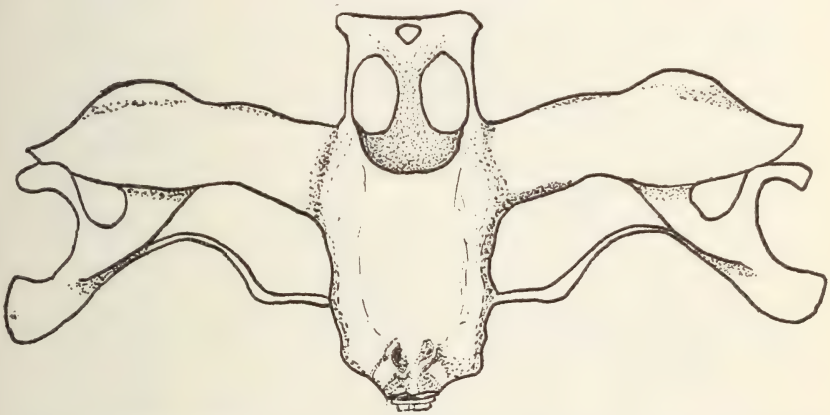


Fig. 4.—*Sphyrna tudes,* dorsal aspect of cranium from 930 mm male collected at Englewood.

grown hammerhead from the African Gold Coast appears the same as heads of Englewood *diplana.* An examination of some Mediterranean specimens in the collection of the British Museum, made for me by Mr. J. R. Norman, shows that two forms are taken there; one is certainly *S. zygaena,* and the second is probably *S. diplana.* These fragmentary data suggest that *S. zygaena* has a more northerly range than *S. diplana,* but that both species may occur in one locality along with *S. tudes.* It is quite possible, however, that the breeding ranges of the three forms are well separated geographically.

[1]Russell J. Coles, "The Large Sharks of Cape Lookout, North Carolina," *Copeia,* No. 69 (1919), pp. 34-43, pls. 2-3.

[2]Lewis Radcliffe, "The Sharks and Rays of Beaufort, North Carolina," *Bulletin U. S. Bureau of Fisheries,* Vol. 34 (1916), pp. 239-284, pls. 38-49.

Adult males of *S. diplana* have been taken at Englewood, and the young of both sexes have been taken at Englewood and in the north Gulf. Separation of *diplana* from *zygaena* must be made here on the basis of characters of the young. In *diplana,* the young of both sexes have the front margin of the head with four lobes, while in *zygaena* the head has three lobes. In *diplana* the teeth have smooth cusps, nearly erect centrally in the lower jaw and having the formula given in the description. In *zygaena* the teeth are finely serrate, recumbent in the lower jaw, and with the typical formula reduced. A series of 10 young *zygaena* from Sandy Hook Bay, New York, have teeth in $\frac{13+2+13}{13+1+13}$ to $\frac{15+0+15}{14+1+14}$ rows. In all of the *diplana* specimens

Fig. 5.—*Sphyrna tudes,* dorsal aspect of cranium from 2300 mm female collected at Englewood.

I have seen, there has been a large hole in the rostral cartilage, and the wings of the preorbital process have had definite inwardly directed points. In the *zygaena* material, only one specimen has shown the hole of the rostral cartilage (1.25 mm in diameter as compared to 5 mm for *diplana* of comparable size), and none have shown the points on the wings of the preorbital processes. The rostral cartilage hole is probably associated with the central notch in the front margin of the head, and the distribution of its occurrence in hammerheads generally suggests independent origins for *diplana* and *zygaena.*

In the Pacific there are at least two forms of the common hammerhead. The young of one form has the three-lobed head associated with recumbent teeth in the lower jaw. If it is to be considered distinct from *S. zygaena,* the name *S. oceanica* should be applicable. *S. lewini* is best known from several papers by Whitley. He states of this species[3] "I think there is one species in Australasia, ... the teeth which are entire in the young become finely denticulated. Further

study of more specimens of various sizes and both sexes will be necessary to determine whether we have more than one species; . . . . . ” The cast of a female about 8 feet long (2.43 meters) is in the Los Angeles Museum of History, Science, and Art and the jaws and skull of the original specimen have been carefully removed and dried. This specimen was collected off San Pedro, California, on July 31, 1940, and apparently agrees in all respects with *S. lewini* as described by Whitley. The species differs from *diplana* in having heavy, serrate teeth, rostral cartilage hole absent, and points on the wings of the preorbital processes absent. The head is four-lobed, but the central notch is less conspicuous than in specimens of *diplana* from Englewood.

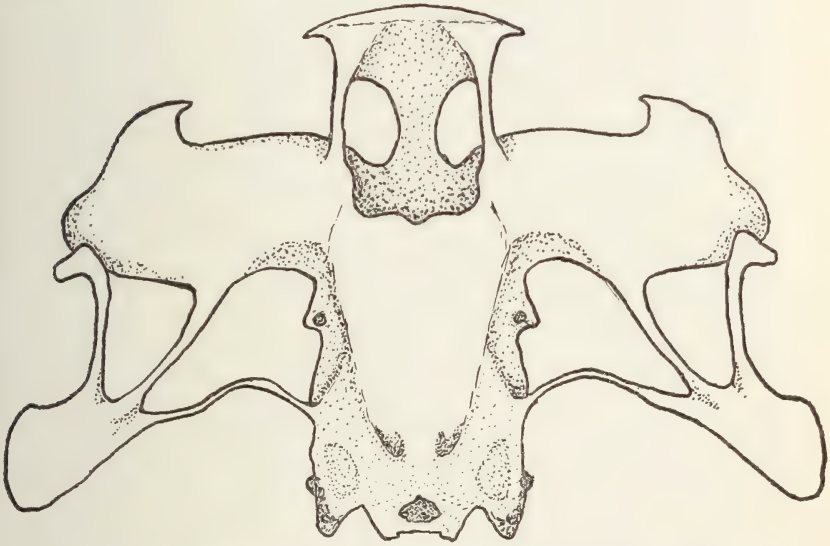


Fig. 6.—*Sphyrno tiburo,* dorsal aspect of cranium from 1070 mm female collected at Englewood.

I have previously reported (p. 162)[4] a slight difference related to sex in the proportions of the head of Englewood *S. tiburo.* This is a scarcely measurable difference, appearing only in averages of measurements of series. I know of no other sex-related dissimilarities reported for the family Sphyrnidae, although sex dimorphism may be suggested by the available data when very large series cannot be

[3]Gilbert P. Whitley, *The Sharks, Rays, Devil-Fish, and other Primitive Fishes of Australia and New Zealand* (“Australian Zoological Handbook, The Fishes of Australia”; Sydney: Royal Zool. Soc. of New South Wales, 1940), p. 121.

studied, as a possible explanation for the appearance of males of one form with females of another in a locality. A fairly extensive collection of sharks made at Englewood in late winter and early spring would probably produce adult males of *S. diplana* and adult females of *S. tudes*, with no other large hammerheads represented. I suspect that some similar condition may be true of the Carolinas with the additional complication of the presence of *S. zygaena*.

[4]Stewart Springer, "Three New Sharks of the genus *Sphyrna* from the Pacific Coast of Tropical America," *Stanford Ichthyological Bulletin*, Vol. 1, (1940), pp. 161-169.

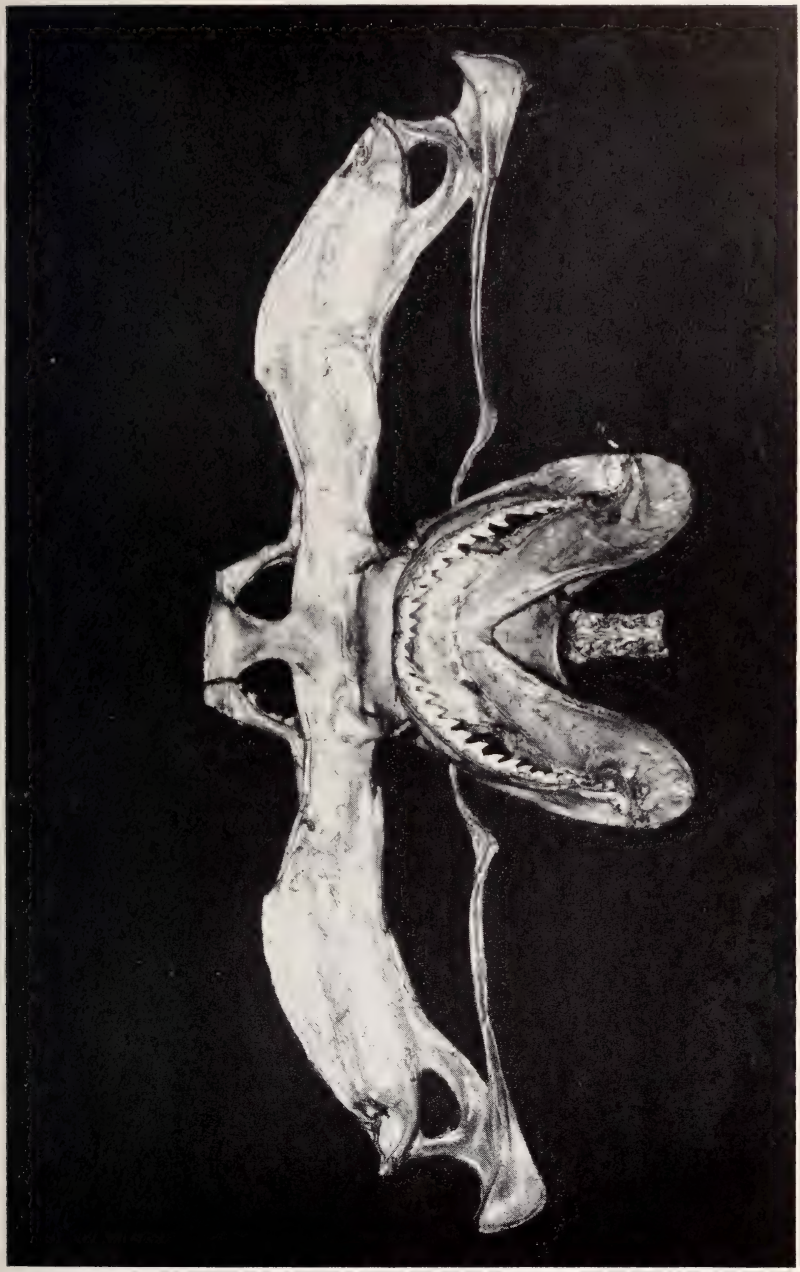


Plate 1.—*Sphyrna lewini*, ventral view of cranium with jaws; from a female about 4 ft. long, collected at San Pedro, California. Photograph by Los Angeles Museum.

ON THE FIRST PLEOPOD OF THE MALE CAMBARI *(DECAPODA, ASTACIDAE)*[1]

HORTON H. HOBBS, JR.
University of Florida

It has long been customary in describing the first pleopod of the male Cambari to refer to the "inner" and "outer" parts. In my work on the crayfishes of Florida I have encountered considerable difficulty in understanding and in making descriptions of the first pleopod with these two terms as a basis of orientation. I wish, therefore, to propose a terminology which I have found to be more satisfactory.

When this paper was written I was unaware of the work of E. A. Andrews on the anatomy of the crayfish pleopod,[2] and it is noteworthy that my interpretation of the first pleopod so closely parallels his. I am retaining my terminology because it more clearly indicates the position of these terminal processes. Included in Andrews' paper is a series of drawings which illustrate excellently the more detailed internal structure of the first pleopod. The subgenus *Bartonius* as used by Andrews = the subgenus *Cambarus;* and *Cambarus affinis* and *Cambarus virilis* = *Faxonius affinis* and *Faxonius virilis* respectively. That further investigation of the first male pleopod should be made is pointed out by Andrews, p. 90.

In examining the first pleopods of many species of *Cambarus* and *Faxonius* I have been impressed by the basic similarity in the structure and arrangements of five terminal processes, and I believe that a terminology which attempts to homologize all of these will provide a working basis that will be more specific in its designations.

The homologies that I think I can discern between the terminal processes are admittedly based wholly upon morphological considerations, and presuppose a prototype which possessed a pleopod with five terminal processes as the type from which all present species of *Ortmannicus*, and very probably the entire Cambarid group, have been derived.

The species, the pleopod of which probably most nearly approaches that of the prototype appendage, is *Cambarus digueti* (See Plate II, figs. 4 and 5). Since the terminal processes of this species are small and crowded, I have figured a hypothetical pleopod in which the relationships of these parts are more diagrammatically shown.

[1]Contribution from the Department of Biology, University of Florida.

[2]E. A. Andrews, "The Anatomy of the Stylets of *Cambarus* and of *Astacus*," *Biological Bulletin of the Marine Biological Laboratory, Woods Hole, Massachusetts,* Vol. 18, No. 2 (1910), pp. 79-97, 5 pls.

For descriptive purposes the first pleopod is considered to be directed ventrad. The caudal surface is thus that surface broken by the longitudinal groove, and the cephalic is that surface which is generally held against the sternum of the thoracic region. I have designated the five processes of the hypothetical generalized pleopod as follows (Plate I, figs. 1, 2, 3, 4): A, the mesial process; B, the cephalic process; CE, the central projection consisting of two processes generally somewhat fused; C, the centro-caudal, and E, the centro-cephalic process; and D, the caudal process.[3] The term *process* is used to indicate any single terminal outgrowth regardless of its nature. The term *projection* refers to a terminal outgrowth consisting of a fusion or partial fusion of two of the terminal processes. In the second form male these processes are sometimes hardly discernible.

These relationships are made clear if one will imagine the pleopod to have been formed by the rolling-up of a flat, double sheet of tissue (Plate I, fig. 3). In many species, if the pleopod be examined under a binocular, the "rolled-sheet-of-tissue" structure is clearly indicated. If the pleopod be now visualized as unrolled and viewed from the inner surface it would present the appearance shown on Plate I, fig. 4. The order of the terminal processes on the roll should be noted. From left to right are: the mesial process, the cephalic process, the centro-caudal process, the caudal process, and the centro-cephalic process.

In several species the pleopod is so modified as to be almost a replica of the hypothetical one. *Cambarus pubescens, Cambarus lucifugus,* and *Cambarus pallidus* may be cited as species which most nearly approximate the hypothetical pleopod in their structure.

In several species the cephalic process is lacking, or it is represented by only a small tubercle. This type of pleopod is exemplified in *Cambarus spiculifer, Cambarus advena,* and *Cambarus rogersi.*

It is not uncommon to find the area from which the caudal process arises so accentuated as to practically lose its characteristics as a process. This condition may be found in the pleopods of *Cambarus advena, Cambarus rogersi* and *Cambarus alleni.*

In certain species extra processes are added between the centro-caphalic and the centro-caudal processes, and in these cases it is sometimes difficult to decide which is the caudal process and which are the adventitious processes. All of the latter are outgrowths from the caudal region, and where there are several of these there is generally one arising from the central part of the knob while the others are

[3]Compared with Andrews' terminology, the mesial process = the spatula; the cephalic process = the scapula; the central projection = the canula; the caudal process = the ligula.

processes from the rim. Such extra processes may be found in *Cambarus pictus, Cambarus spiculifer, Cambarus clarkii paeninsulanus,* and many others.

In the subgenus *Cambarellus,* of which I have studied only *Cambarus shufeldtii* and *Cambarus montezumae,* only the cephalic process is lacking. The caudal process is more spiculiform in this subgenus than in any of the other subgenera.

The subgenus *Procambarus* possesses all five of the terminal processes, though in every case the caudal process is much reduced. This statement is based on examination of *Cambarus cubensis, Cambarus digueti,* and *Cambarus mexicanus.* In *Cambarus digueti* the caudal process is practically obsolete. In *Cambarus cubensis* and *Cambarus mexicanus* it is represented by a rounded knob on the lateral margin of the appendage.

I have only one specimen of the single species, *Cambarus paradoxus,* belonging to the subgenus *Paracambarus,* and this specimen is a male of the second form. As was stated above it is often difficult to identify the processes in the second form male, and little can be made out on the specimen I have before me; but I strongly suspect that this species, and therefore this subgenus, possesses all five of the terminal processes.

Deviations from the generalized type of pleopod consisting of the loss of one or more of the terminal processes result usually in the disappearance of either the cephalic process or of the cephalic and the caudal processes. If only one is lacking it is always the cephalic process so far as I have observed.

As has been pointed out, though I have only morphological evidence for the suggested homologies in the terminal processes of the first pleopod of the Cambari, I have found that there is a striking similarity despite the prodigious variation which occurs in this appendage throughout the species of this group. Further, as has been stated above, I believe that this terminology will prove far more satisfactory than any hitherto used.

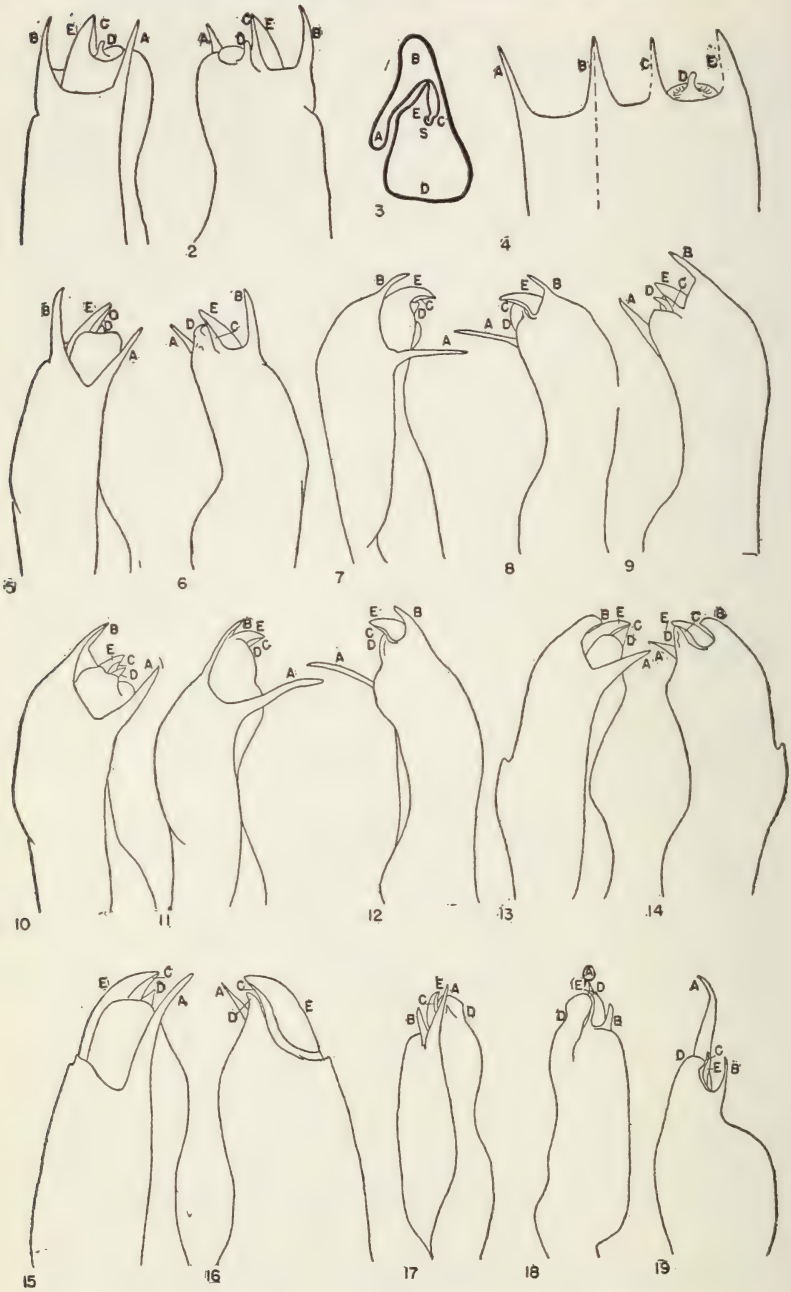


PLATE I

PLATE I

First Left Pleopods of First Form Males

A—mesial process
B—cephalic process
CE—central projection
C—centro-caudal process
E—centro-cephalic process
D—caudal process

Fig. 1.—Mesial view of hypothetical generalized pleopod.
Fig. 2.—Lateral view of hypothetical generalized pleopod.
Fig. 3.—Cross section through hypothetical generalized pleopod.
Fig. 4.—Unrolled hypothetical generalized pleopod.
(For reconstruction: Roll to the left and toward the observer the end bearing process E so that the broken line at E will be superimposed on the broken line at C. Fold A to the right and toward the observer along broken line in process B. The fold along B will be cephalic and D will be caudal.)
Fig. 5.—Mesial view, *Cambarus pubescens.*
Fig. 6.—Lateral view, *Cambarus pubescens.*
Fig. 7.—Mesial view, *Cambarus lucifugus alachua.*
Fig. 8.—Lateral view, *Cambarus lucifugus alachua.*
Fig. 9.—Lateral view, *Cambarus pictus.*
Fig. 10.—Mesial view, *Cambarus pictus.*
Fig. 11.—Mesial view, *Cambarus pallidus.*
Fig. 12.—Lateral view, *Cambarus pallidus.*
Fig. 13.—Mesial view, *Cambarus clarkii paeninsulanus.*
Fig. 14.—Lateral view, *Cambarus clarkii paeninsulanus.*
Fig. 15.—Mesial view, *Cambarus spiculifer.*
Fig. 16.—Lateral view, *Cambarus spiculifer.*
Fig. 17.—Mesial view, *Cambarus gracilis.*
Fig. 18.—Lateral view, *Cambarus gracilis.*
Fig. 19.—Lateral view, *Cambarus alleni.*

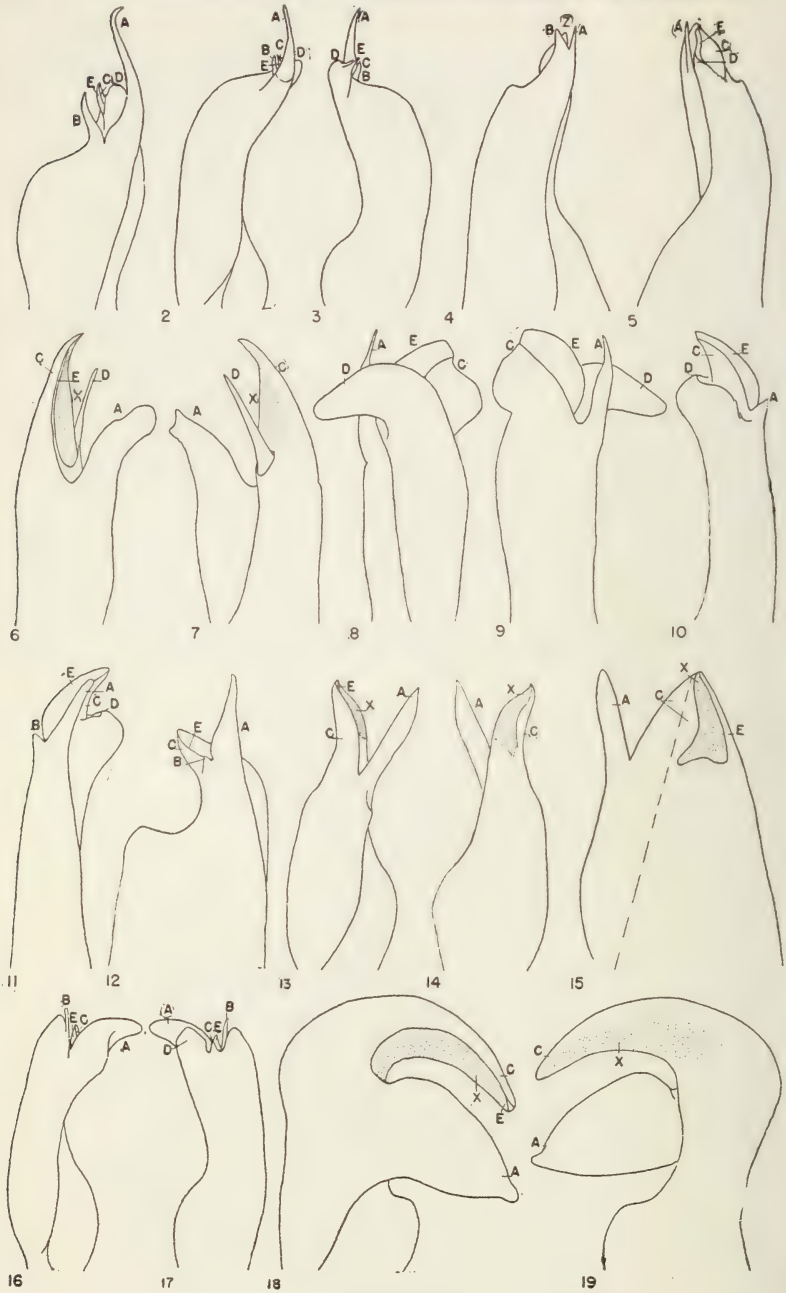


PLATE II

PLATE II

First Left Pleopods of First Form Males
A—mesial process
B—cephalic process
CE or Z—central projection
C—centro-caudal process
E—centro-cephalic process
D—caudal process
X—a membranous sheath stretched beteween E and C.

Fig. 1.—Mesial view, *Cambarus alleni.*
Fig. 2.—Mesial view, *Cambarus barbatus.*
Fig. 3.—Lateral view, *Cambarus barbatus.*
Fig. 4.—Mesial view, *Cambarus digueti.*
Fig. 5.—Lateral view, *Cambarus digueti.*
Fig. 6.—Mesial view, *Cambarus montezumae.*
Fig. 7.—Lateral view, *Cambarus montezumae.*
Fig. 8.—Caudal view, *Cambarus rogersi.*
Fig. 9.—Cephalo-mesial view, *Cambarus rogersi.*
Fig. 10.—Lateral view, *Cambarus advena.*
Fig. 11.—Mesial view, *Cambarus advena.*
Fig. 12.—Mesial view, *Cambarus mexicanus.*
Fig. 13.—Mesial view, *Faxonius limosus.*
Fig. 14.—Lateral view, *Faxonius limosus.*
Fig. 15.—Diagram of "unrolled" appendage of *Faxonius limosus.* (For reconstruction: Roll the right margin toward the observer and bring it into contact with the broken line; then fold the structure toward the observer along the broken line.)
Fig. 16.—Mesial view, *Cambarus kilbyi.*
Fig. 17.—Lateral view, *Cambarus kilbyi.*
Fig. 18.—Mesial view, *Cambarus bartonii* subspecies.
Fig. 19.—Lateral view, *Cambarus bartonii* subspecies.

NOTES ON THE DISTRIBUTION AND HABITS OF THE FERNS OF NORTHERN PENINSULA FLORIDA

STEPHEN H. SPURR
Harvard Forest

Studies of the distribution and habits of the ferns of the order Filicales in northern peninsular Florida were made by the author during the winter of 1938. This paper is based upon the results of these field studies, supplemented by published information, and by data obtained from the records of Mr. Edward P. St. John of Floral City, Florida, and from the herbaria of the Florida Agricultural Experiment Station and the Department of Botany of the University of Florida. Mr. St. John, Mr. Erdman West of the Experiment Station, and Professor Madison D. Cody of the Department of Botany were liberal in their assistance to the author. Dr. T. H. Hubbell of the Department of Biology of the University, has generously read and criticized the manuscript.

From the standpoint of ferns, much of northern peninsular Florida has been inadequately explored and would repay more intensive collecting, especially with reference to the numerous minor limestone exposures. There still remains a great deal of work to be done before the range, abundance and habits of the ferns of this region are satisfactorily understood.

The ferns of the order Filicales known to be native to northern peninsular Florida can, on the basis of their distribution, be classified into four rather distinct ecological groups. The first group, hereinafter called the *cool-temperate* ferns, includes a number of species that have their centers of distribution north of the region in question, and southern limits of distribution that fall in that region. Another group, here called the *warm-temperate* ferns, is made up of species that range throughout the area and constitute the dominant fern flora there. A third group, designated as *subtropical,* contains species with northern limits of distribution in the northern part of the Peninsula. These are, in most instances, increasingly abundant southward, and many have their centers of distribution in the southern tip of Florida. The last group, classed as *tropical* ferns, comprises a number of species which, in the northern part of the Peninsula, occur only where the microclimate is more or less tropical in character. Some of these are restricted to northern peninsular Florida, while others also occur on the Florida Keys or in the hammocks of the lower Everglades, but are

not found in the intervening area. In the northern part of the Peninsula most of the tropical species inhabit cave-mouths and other protected limestone outcrops, in contrast to the habits of the subtropical ferns which are predominantly hammock and swamp plants.

The best general treatment of the ferns of Florida, including full descriptions of all the species discussed in this paper, will be found in J. K. Small's *Ferns of the Southeastern States* (Lancaster, Pa. Science Press, 1938). Since Dr. Small did not accept the rules of nomenclature promulgated by the Botanical Congress of 1930, a few of his names differ from those accepted by the majority of botanists and used in the present paper. In Small's book *Thelypteris palustris* is called *Thelypteris Thelypteris, Pteridium latiusculum* is called *Pteris Latiuscula,* and the genus *Pteris* is called *Pycnodoria.*

COOL-TEMPERATE FERNS

The six ferns of this group are of uncommon occurrence in northern peninsular Florida. The range of the ebony spleenwort has not been definitely determined but the species extends at least as far south as Pasco County. Although the southern limit of occurrence of the lowland lady fern lies in Alachua County, it is quite common in that vicinity. The other ferns in this group have been found only at a few scattered localities. These stations seem to represent isolated outposts beyond the well-marked southern limit of distribution for these species.

Trichomanes Petersii A. Gray. Peters' filmy fern. This is very rare throughout its range, being known only from a few stations in Alabama (where it was first discovered), South Carolina, Tennessee, Georgia, Mississippi and Illinois. In these states it usually frequents moist locations on the undersides of dripping rocks, or rocks near waterfalls where the air approaches the saturation point. The species is known from only one Florida station, near Brooksville, where it was found by Mr. Edward P. St. John in 1936. Peculiarly enough, it here inhabits a moderately dry hammock on a rocky hill, and grows on detached rocks at some distance from water.

Adiantum Capillus-Veneris L., the rare Venus' Hair, mingles in Florida with tropical species on moist lime-rock. In Annuttalagga Hammock at its southernmost station in the United States, it covers the walls of a gently sloping fissure leading down into a cave.

Occurrence: Alachua Co.: Devil's Mill Hopper. Citrus Co.: Sulfur Springs. Hernando Co.: Venus' Hair Sink; Annuttalagga Hammock. Rare northward.

Asplenium platyneuron (L.) Oakes, the ebony spleenwort, is not as abundant in Florida as in the northern states; but around Gainesville it is common in most hammocks and along railway em-

bankments. There seem to be two distinct forms of this fern in Florida. One is a small typical form with dimorphic fronds which grows only on rocks, and the other a large ground-loving form with all the fronds fertile.

Athyrium asplenioides (Michx.) Eaton., the lowland lady fern, is another cool-temperate fern frequently found around Gainesville. It grows only in moist hammocks and in wet woods, and has not been found south of Alachua County.

Occurrence: Alachua Co.: Hammock west of clay tennis courts, University of Florida; Ft. Clark Church; Sanchez Hammock. Common northward.

Polystichum acrostichoides (Michx.) Schott., the evergreen Christmas fern, has been collected in several rich hammocks in the Peninsula, but no specimens have been found there that were healthy or overly well-developed.

Occurrence: Hernando Co.: Annuttalagga Hammock. Citrus Co.: Pineola. Alachua Co.: Beech Hammock near Santa Fe.

Lygodium palmatum (Bernh.) Sw. Climbing fern. It is yet undetermined whether the climbing fern is native to northern peninsular Florida. Two of the three stations for it very likely represent escapes from cultivation, and its occurrence at a third may have resulted from migration from one of the others. In this area it is a vine, twining around broad-leaved trees in fairly moist locations and in abandoned rock-pits.

Occurrence: Alachua Co.: Gainesville; northeast of Alachua Sink. Citrus Co.: Hernando Village.

WARM-TEMPERATE FERNS

All the ferns of this group occur in greater or lesser abundance throughout the northern part of the Florida peninsula.

Marginaria polypodioides (L) Tidestom., the resurrection fern, is very abundant in this region. A form altogether restricted to hammocks, it is particularly common on leaning trunks of magnolia, sweet-gum, live-oak and other broad-leaved trees, although it is found also on dead stumps, fallen trees, logs, and rarely on the ground or on rock.

Pteridium latiusculum (Desv.) Hieron., the bracken, is without doubt the commonest fern in this area. It appears to reach its best growth in the open flatwoods where it often covers the ground to the exclusion of other vegetation. Although at home in both moist and semi-arid plant zones, it evidently demands a rather large amount of sunlight. Lack of sufficient sunlight seems to account for its relative scarcity in hammocks.

Anchistea virginica (L.) Presl. and *Lorinseria areolata* (L.) Presl., the two chain-ferns that occur in this state are primarily marsh or swamp plants. *Anchistea* is capable of thriving in soil saturated with water, and is abundant in nearly all wet hammocks, cypress-bays, swamps, marshes and prairies. Abundant.

Lorinseria, however, is more of a mesophytic form, and does not thrive in standing water. It is most common in moist but well aerated locations with markedly acid soils. Abundant.

The two Osmundas in this region are largely hammock plants. *Osmunda cinnamomea* L., the cinnamon fern, is the more mesophytic, and is common in nearly all the mesophytic hammocks.

Osmunda regalis L., the royal fern, on the other hand, grows luxuriantly in saturated soils. Although it can thrive under conditions of limited light and excess moisture, it is not as abundant as either of the chain-ferns, which have similar requirements and habits.

The woodferns are a large group presenting much taxonomic difficulty. Knowledge concerning the habits and distribution of the individual species must necessarily be scanty until the component species have been clearly differentiated. With one exception, the woodferns are forest-dwellers. The one exception is the common marshfern, *Thelypteris palustris* Schott, which demands moisture and light. Predominantly a northern form, it has established itself throughout most of Florida, and is common in the upper portion of the peninsula.

In contrast to the habits of the marshfern, the common woodfern of this region, *Thelypteris normalis* (C. Chr.) Moxley, is typically a hammock form, occurring outside of hammocks only around the mouths of caves or on other exposed limestone. Practically every hammock is a *Thelypteris normalis* habitat, although the fern is most abundant on calcareous soils. Sometimes what appear to be stunted light-green fronds of *Thelypteris normalis* are found on vertical rock walls. These cliff woodferns belong to a recently distinguished species, *Thelypteris saxatilis* R. St. John. Few.

Thelypteris dentata (Forsk.) E. St. John, the true dentate woodfern, is rather rare, but may be found in rocky hammocks within which are steep slopes. A species recently separated from it, *Thelypteris versicolor* R. St. John, also occupies only rich well-shaded hammocks, but in general thrives on drier ground than the moisture-loving dentate woodfern. Many of the past records for *Thelypteris dentata* were based on what is now recognized as *Thelypteris versicolor*.

Another recently distinguished woodfern is *Thelypteris ovata* R. St. John, intermediate in form between *Thelypteris normalis* and

Thelypteris augescens (Link) Munz & Johnston. This species is common in the same localities and habitats as *Thelypteris normalis*, with which it is easily confused.

Dryopteris ludoviciana (Kunze) Small., the Florida woodfern, is, next to *normalis*, the most common woodfern in northern peninsular Florida. It is not common north of the Peninsula, however, nor is it found south of the Okeechobee region.

The commonest Aspleniums in the upper part of the peninsula are the black-stemmed spleenworts, *Asplenium resiliens* Kunze and *Asplenium heterochroum* Kunze. Although quite distinct farther north in their range, in Florida they are almost inseparable. Both grow only on exposed rock in protected locations, and one or the other is common in most rocky hammocks and on most rocky river bluffs throughout the northern half of Florida.

SUBTROPICAL FERNS

In marked contrast to the members of the preceding group, the subtropical ferns as a whole are distinctly uncommon in the northern part of the peninsula, where, by definition, their northern limit of distribution lies. Several of the species, however, are common in the southern part of the area under discussion.

The fronds of *Acrostichum daneaefolium* Langsd. & Fisch., the leather fern, sometimes reach a height of nearly twelve feet, it being the largest of our native ferns. The plant is markedly hydrophytic, and thrives in either fresh or slightly brackish marshes, swamps, low prairies and wet hammock.

Occurrence: Citrus Co.: Homosassa Springs. Marion Co.: Withlacoochee River east of Dunnellon. St. Johns Co. Volusia Co. Common southward.

Polypodium pectinatum L., a polypody extends north only as far as the lake region of central Florida, but is locally abundant there. It thrives on humus or rotting logs or stumps, a characteristic which aids one in separating it from its close relative, *Polypodium plumula* Humb. & Bonpl., another polypody which is a smaller lime-rock dwelling form. In favorable locations *Polypodium pectinatum* may reach considerable size, a specimen collected by the author in Seminole County measuring five feet, two inches in length.

Occurrence: Citrus Co. Hernando Co.: Annuttalagga Hammock. Pasco Co.: Blanton. Lake Co.: Seminole Springs. Putnam Co. St. Johns Co. Common southward.

One of the few true epiphytes ranging into northern peninsular Florida is the golden polypody or serpent fern, *Phlebodium aureum* (L) J. Smith. It is largely confined to those cabbage palms of which the crowns are twenty or more feet above the ground. Toward its

northern limit it sometimes forsakes this habit, having been found growing on live-oak trees ten to fifteen feet from the ground, and in humus on the hammock floor.

Occurrence: Dixie Co.: on live oak, Cross City. Alachua Co.: Prairie Creek; Santa Fe River at Camp Oleno. Duval Co.: mouth of St. Johns. Marion Co.: Juniper Springs. Lake Co.: Seminole Springs. Levy Co.: Gulf Hammock. St. Johns Co. Common southward.

Another epiphytic species is *Campyloneurum Phyllitidis* (L) Presl., the strap-fern. It is a hammock form, rare in the northern part of the peninsula where it grows most commonly on live-oaks and similar rough-barked trees. It is, however, sometimes found on the hammock floor, on logs, and on stumps.

Occurrence: Citrus Co.: Sulfur Springs. Lake Co.: Rock Springs. Duval Co. Marion Co. St. Johns Co.

Vittaria lineata (L.) Sw., the shoestring fern, is another epiphyte, one which has very similar habits to the golden polypody. It has not, though, the marked height requirements that have been noted for the latter fern. Not only does it hang from the base of the crown of the cabbage palm but it has also been found growing on the trunk at some distance (at least eight feet) from the ground. One station is known in Citrus County where it grows on rock, and another where it grows on a rotting stump. At neither place are the plants well developed. It is very abundant along the Econlockhatchee River west of Chuluota, Seminole County. There it is associated with *Phlebodium aureum* and *Cheiroglossa palmata,* the handfern.

Blechnum serrulatum L. C. Rich., the swamp fern, is typically an inhabitant of fresh-water swamp or marsh. Where the water is slightly brackish, it grows on top of stumps or cypress knees. A line south of and roughly parallel to the Withlacoochee River marks its northern limit of distribution.

Occurrence: Citrus Co.: Crystal River; Homosassa Springs. Hernando Co.: Brooksville. Putnam Co. St. Johns Co. Abundant southward.

The confusion that has existed concerning the taxonomy of the woodferns has made many past records of doubtful value. *Thelypteris augescens* (Link) Munz & Johnson, until recently known only from the Everglades, has been found at several stations in the west-central part of the peninsula (Alachua, Citrus, Dixie and Sumter Counties), but its distribution remains to be worked out. It has been found growing on the hammock floor, in rock pits, and on stony bluffs. *Thelypteris gongylodes* (Schkuhr) Kuntze, a hydrophytic plant occurring in low hammocks, marshes and swamps, reaches about as far north as the latitude of Leesburg. It is rather common southward.

Occurrence: Citrus Co.: Crystal River (?); Homosassa. Sumter Co.: Weed's Landing. Shell Island in Withlacoochee River. Volusia Co.: Lake Helen. Orange Co. Pasco Co. Seminole Co.

Only three specimens of *Thelypteris macilenta* E. St. John have been discovered. These were found growing together in Annuttalagga Hammock in Hernando County in 1936. Only the one specimen transplanted and growing in Floral City is known to be still in existence.

Occurrence: Hernando Co.: One colony, northwest portion of Annuttalagga Hammock.

The determination of certain specimens collected near Brooksville as *Thelypteris unca* R. St. John is still dubious, and the occurrence of this plant in northern peninsular Florida therefore remains questionable. *Thelypteris tetragona* (Link) Small is known only from Marion, rocky slopes in hammocks. *Thelypteris panamensis* (Presl.) E. St. John has been found only at two stations, one near Fort Meade and the other south of Lakeland, both in "miry hammocks" along the Peace River.

Dryopteris setigera (Blume) Kuntze has been classified as an introduced species, but considerable evidence exists that it may be native. It grows in the Lake Region from Seminole and Orange Counties south of Polk County, and westward to Citrus and Hernando Counties. Its preferred habitat is a deep hammock. Individual fronds may exceed five feet in length.

Occurrence: Hernando Co. Orange Co. St. Johns Co. Seminole Co. Volusia Co. Polk Co. Citrus Co.

Interesting gradations of habit are exhibited by *Nephrolepis exaltata* (L.) Schott, the wild Boston fern. In the Everglades hammocks it is most common on trees. As one progresses northward, it is found to seek lower levels on trees, until, at about the latitude of Floral City all the stations are on the ground. Still farther north, it grows mostly in wells in pinewoods below the general ground surface. The most northern station known is Jenning's Cave in Marion County.

Occurrence: Marion Co.: Jenning's Cave. Citrus Co.: Homosassa Springs. Hernando Co.: Prospecting well, Annuttalagga Hammock. Sumter Co.: Swamp near Cedar Hammock.

Nephrolepis biserrata (Sw.) Schott., the sword fern, has been reported from one station on an island in the river below Homasassa Springs in Citrus County. The identification is not fully authenticated. No other station is known north of the Everglades.

TROPICAL FERNS

As the so-called tropical ferns of northern peninsular Florida are generally quite exacting in their choice of habitat, and as climatic conditions in that region appear to be generally unfavorable to them, these

ferns as a whole are decidedly uncommon and their occurrence is generally spotty.

The filmy-fern, *Trichomanes sphenoides* Kunze, has been found in the West Indies and Central America, but only one station is known for it in Florida. This is in Sumter County, where it clings to a few limestone boulders on a dry shaded knoll.

Occurrence: Sumter Co.: 7 miles east of Floral City.

Ceratopteris pteridoides (Hook.) Hieron, the floating fern, is abundant in the headwaters of the St. Johns River. It is also known from pools near Pineola Grottoes in Citrus County, and in the upper waters of the Withlacoochee River. The fern is annually winter-killed, but vegetative buds sink into the mud in the fall and rise to the surface early in the sprng to produce a new crop.

In the United States, the Florida anemia, *Anemia adiantifolia* (L.) Sw., was until recently known only from the pinelands and hammocks in the Everglades Keys. It is known now to be quite common in the lower part of the peninsular lime-sink region in Citrus and Hernando Counties, where it is generally found growing on rock ledges in deep and well-shaded ravines.

Occurrence: Citrus Co.: Ravine near road, 2 miles north of Pineola; rock ledges, Lecanto; Sulfur Springs. Few. Hernando Co.: Few.

Polypodium plumula is similar in appearance to *Polypodium pectinatum* (discussed above as a subtropical fern), but is distinct in both habits and distribution. *Polypodium plumula* is the rarer of the two species. It has been found only in a few widely separated localities. Besides growing on the upper Florida Keys and at points along the lower east coast, it has been recorded from three stations in Alachua County, from four or five in Citrus County, and from a few more in neighboring territory. A hammock plant, it prefers lime-rock in the northern part of the peninsula, but tends to grow in trees or on rotting logs or humus further south.

Occurrence: Alachua Co.: Alachua Sink; Devil's Mill Hopper, on oak; Buzzard's Roost. Citrus Co.: Pineola and other grottoes Hernando Co.: Annuttalagga Hammock, on rock; Choocochattee Hammock near Brooksville. Marion Co. Orange Co. St. Johns Co. Seminole Co. Sumter Co. Volusia Co.

Pteris cretica L., the Cretan brake, is typically a tropical fern; it has migrated, however, probably with the aid of man, into restricted localities in western Florida and in southern Georgia. It grows on exposed lime-rock or on the humus covering exposed lime-rock in deep rocky hammock, in lime-sinks, and in grottoes in northern peninsular Florida.

Occurrence: Alachua Co.: Buzzard's Roost; Devil's Mill Hopper; Palisade Sink. Citrus Co.: Pineola and other grottoes. Columbia Co.: Old Santa Fe River bed. Hernando Co. Marion Co.

Although the Venus' Hair and the Florida maidenhair, *Adiantum tenerum* Sw., grow in the same region, and in at least one station occur together in the same lime-sink, the Venus' Hair reaches Florida from the Appalachian region, while the Florida maidenhair extends north from the tropics, where it is widely distributed. *Adiantum tenerum* Sw. is rather the more common species but is restricted to a much smaller area in Florida. It grows most abundantly in heavy shade on honeycombed rock below general land level.

Occurrence: Alachua Co.: Small sink south-east of Alachua Sink; Devil's Mill Hopper. Citrus Co.: Pineola Grottoes; Metz Grotto. Hernando Co.: Vittaria Sink, Annuttalagga Hammock; Maidenhair Sink, Annuttalagga Hammock. Marion Co. St. Johns Co. Volusia Co.

Hypolepis repens (L.) Presl., the spring fern, shows a marked preference for seepage areas at the heads of ravines. Although discovered in Florida in 1895, it was known only from one or two stations in central Florida until quite recently, when it was found to be fairly widely established in eastern Hernando and Polk Counties. Outside of central Florida it is known from Gold Head Branch in Clay County about a hundred miles farther north.

Occurrence: Clay Co.: Gold Head Branch State Park. Polk Co.: near Lakeland. Hernando Co.: Choocochattee Hammock. Pasco Co.: Dade City. Orange Co. Osceola Co. Putnam Co. Seminole Co.

Blechnum occidentale L. is a West Indian and South American fern that was not found in Florida until 1916. In addition to the original station near Brooksville, two other stations have been found for it in Hernando County and one in Alachua County. In Hernando County it grows near streams in rocky, shaded places; at the Alachua County station it covers a perpendicular wall about ten feet below the ground level in a large cave entrance.

Occurrence: Alachua Co.: Fern Cave. Hernando Co.: Choocochattee Hammock; Annuttalagga Hammock; four miles north of Brooksville.

As a group, the tropical spleenworts in northern peninsular Florida are of rare occurrence. The commonest species is perhaps *Asplenium abscissum* Willd., which is known from upwards of thirty stations. In general, this fern can withstand more light, steeper walls, and drier conditions than any others of the group. It reaches its best growth, however, in the half-shade of overhanging lime-rock walls dripping with moisture. In some of the deep natural wells of Alachua County it completely hides the walls.

Occurrence: Alachua Co.: Coral Snake Wells; Buzzard's Roost; Abscissum Sink; Goat Sink; Fern Cave; Grape-vine Sink; several additional. Marion Co.: Jenning's Cave; Belleview; Indian Cave; Hayes Cave. Citrus Co.: Pineola. Lecanto. Hernando Co.: Devil's Punch Bowl, Annuttalagga Hammock; Venus' Hair Sink, Annuttalagga Hammock. Sumter Co.: Panasoffkee Outlet.

Asplenium verecundum Chapm., has a wider distribution than *Asplenium abscissum* but is less abundant locally. About a dozen stations have been recorded. It seems to thrive in the pits of sheer lime-rock walls, only if the walls are well protected by trees. It reaches its best growth in the Citrus County grottoes and at Buzzard's Roost in Alachua County.

Occurrence: Alachua Co.: Split Rock; Buzzard's Roost; Devil's Hole; Jook Cave. Marion Co.: Bellview Cave; Indian Cave. Columbia Co.: Old Santa Fe River bed. Sumter Co.: Wahoo. Citrus Co.: Lecanto. Hernando Co.

For the endemic *Asplenium Curtissii* Underw. only five stations are known, and only at Pineola Grottoes and at Buzzard's Roost does it occur in any abundance. Its habits are very similar to those of *Asplenium verecundum.*

Occurrence: Alachua Co.: Buzzard's Roost. Marion Co.: Belleview Cave. Citrus Co.: Lecanto; Pineola Grottoes. Sumter Co.: Indian Field ledges north of Wahoo. Hernando Co.

Asplenium auritum Sw. has only been found at two places within two miles of each other along the Hillsborough River south of Zephyrhills. Here it is epiphytic on very large live-oak trees. There is also an extinct station in Cedar Hammock in Sumter County.

A very delicately cut little fern, *Asplenium cristatum* Lam., has been found at only six stations in Citrus and Sumter Counties all within a radius of less than five miles. Around the southern end of Lake Tsala Apopka, this fern grows on protected rocks in deep hammocks. It seems to grow only upon chert and flint—siliceous—outcrops.

Occurrence: Citrus Co.: Rock Island; "The Cove"; Craig's Island. Sumter Co.: Panasoffkee Outlet.

Until 1935, *Asplenium pumilum* Sw. was known only from Buzzard's Roost in Alachua County, where it grows on scattered siliceous rocks along the top of the ledges. Since then, two other stations have been found, at both of which the ferns grow on scattered siliceous boulders.

Occurrence: Alachua Co.: Buzzard's Roost. Citrus Co.: Craig's Island. Hernando Co.: Annuttalagga Hammock.

Three spleenworts, *Asplenium scalifolium* E. St. John, *Asplenium subtile* E. St. John, and *Asplenium plenum* E. St. John, are not only among the most recently discovered but also among the rarest of our ferns. They were found in 1936 in a cave near Lecanto, Florida. The cave opens off a natural well about forty feet deep. About twenty feet down, on a narrow ledge, these three ferns eke out a precarious existence. In 1938, an additional station was found for *A. subtile* in Fern Cave in Alachua County.

Tectaria heracleifolia (Willd.) Underw., the halberd-fern, is a striking leaf-like grotto plant that in our range is known only from Citrus and Hernando Counties. The three stations for it in Citrus County are the Knight, Metz, and Pineola Grottoes. In Annuttalagga Hammock it is fairly common in and on the edges of shallow lime-sinks.

In the Everglades Keys, *Goniopteris reptans* (J. F. Gmel.) Presl., the creeping-fern, occurs in all of the high pine-land hammocks. In the lime-sink region of northern and central Florida it was formerly considered to be quite rare. In the last few years, however, it has been found to be a relatively common plant in this region also, there being over thirty stations for it in Alachua County alone. It prefers perpendicular rock walls, but makes no particular claim for either moisture or shade.

Occurrence: Alachua Co.: Buzzard's Roost; Coral Snake Wells; Jerome Sink; Quarry Sink; Bat Cave; Grape-vine Sink and others. Citrus Co.: Pineola Grottoes; Sulfur Springs. Marion Co.: Cave at Shady Hill Dairy Farm, Ocala. Hernando Co.

INTRODUCED SPECIES

Nephrolepis cordifolia (L) Presl., Boston Fern.
Pteris Multifida Poir., Spider Brake.
Pteris vittata L., Ladder Brake.

Of the introduced ferns thriving in northern peninsular Florida, the Boston fern (*Nephrolepis cordifolia*) is the best known. It originated as a sport of *Nephrolepis exaltata*. It is quite common, especially in abandoned dumps among other habitats.

Only one station is known for *Pteris multifida*, that being a rock pit near a one-time commercial nursery in Citrus County, one mile east of Inverness. The ladder brake, *Pteris vittata*, may possibly be a native species. It has been found on brick walls, in cemeteries, and in mine pits throughout Florida and in several other southern states.

Occurrence: Alachua Co.: Brick wall, Agricultural Building, University of Florida. Sumter Co.: Mine-pit, north of road, Rutland to Wildwood. Few throughout region.

FLORIDA'S GEOLOGICAL STRUCTURE AND GRAVITY

Robert B. Campbell
Peninsular Oil and Refining Company
Tampa, Florida

In attempting to arrive at a geological interpretation of gravity data the usual assumption is that the maxima are indicative of structural highs. As early as 1890 gravity measurements were used in studying major tectonic features. Hayford and Bowie, geodesists, discussed the relationship of gravity data with local geologic structure and made the first isostatic studies in 1909 and 1910. G. K. Gilbert, a little earlier, concluded that the contoured gravity map of the entire nation indicates the topography of the basement rocks and reflects subsurface structure. Though recognizing that under some conditions this may not be true, most geologists accept Gilbert's idea as a good working hypothesis. Woollard has given this conception expression with the statement that there exists a definite relationship between gravity and geological structures with the gravity profiles in general representing the configuration of the crystalline basement. This relationship is revealed by the relative value rather than by the sign of the anomalies. The anomalies are determined almost entirely by the density and thickness of the material adjacent to and underlying the station. The basement structures may be obscured by the presence of abnormal- or subnormal-density material overlying it, a condition that must be interpreted by evidence of a geological nature, either as exposed at the surface or revealed in well logs.[1]

Geologists accept the idea that peninsular Florida is anticlinal and that west Florida has a regional dip to the south-southwest. If the relationship assumed to exist between structure and gravity were true the gravity values should diminish coastward in any profiles drawn in such direction. As a matter of fact, however, they only do so until the coastline is neared, at which point they suddenly increase in value, making a gravity trough marginal to the coast. This occurs at all points on both the Atlantic and Gulf coasts where there are sufficient data on which to draw profiles. The purpose of this paper is an attempt to pose rather than to solve the problem. Frequent contributions are being made to geologic and geodetic literature in an attempt to learn what gravity anomalies mean in terms of rock mass and structure, and it is hoped the present paper will be an addition to this literature.

[1]G. P. Woollard, "An interpretation of gravity in terms of local and regional structures," *American Geophysical Union Transactions* (1936).

TABLE 1

No.	Name	Latitude	Longitude	Anomaly: Free Air Bouguer		Isostatic: Indirect	56.9 Km.	96 Km.	113.7 Km.
	Profile #1								
356	Capell, Ala.	31/56.5	87/21.0	-.003	-.010	-.007	-.007	-.010	-.011
749	Megargel, Ala.	31/22.7	87/25.4	-.001	-.015	-.013	-.012	-.016	-.017
751	Robinsonville, Ala.	31/05.8	87/26.2	-.016	-.025	-.025	-.024	-.028	-.030
755	Muscogee, Ala.	30/36.5	87/24.9	-.012	-.014	-.020	-.018	-.022	-.024
164	Pensacola, Fla.	30/24.5	87/12.9	-.004	-.004	-.012	-.010	-.015	-.016
	Profile #2								
905	Eufala, Ala.	31/53.6	85/08.4	+.029	+.012	+.018	+.019	+.015	+.014
904	Abbeville, Ala.	31/34.6	85/15.8	+.027	+.013	+.018	+.020	+.016	+.014
886	Dothan, Ala.	31/11.3	85/24.2	+.002	-.009	-.007	-.006	-.010	-.011
885	Munford, Fla.	30/59.8	85/12.6	-.010	-.016	-.016	-.015	-.019	-.021
390	Marianna, Fla.	30/46.5	85/14.1	-.015	-.021	-.022	-.021	-.025	-.027
884	Sink Creek, Fla.	30/37.4	85/09.1	-.039	-.041	-.044	-.042	-.046	-.048
883	Bloomistown, Fla.	30/26.3	85/02.8	-.026	-.028	-.032	-.031	-.035	-.036
882	Idlewood, Fla.	30/11.3	85/11.9	-.015	-.017	-.024	-.022	-.026	-.028
881	Sawmill, Fla.	29/57.7	85/10.6	-.012	-.012	-.021	-.019	-.024	-.026
4	Appalachicola, Fla.	29/43.5	84/58.8	+.012	+.011	+.002	+.004	-.001	-.003
	Profile #3								
876	Tifton, Ga.	31/27.9	83/30.7	+.055	+.042	+.046	+.047	+.043	+.041
877	Alapaha, Ga.	31/23.0	83/12.5	+.033	+.023	+.025	+.027	+.022	+.020
878	Pearson, Ga.	31/17.6	82/49.9	+.025	+.018	+.017	+.019	+.015	+.013
864	Waresboro, Ga.	31/14.2	82/26.0	+.006	000	-.002	-.001	-.005	-.007
865	Ft. Mudge, Ga.	31/03.9	82/11.1	+.014	+.009	+.004	+.006	+.002	000
866	Folkston, Ga.	30/49.6	82/00.3	+.008	+.005	-.001	+.001	-.004	-.006
867	Hilliard, Fla.	30/42.1	81/55.5	+.009	+.007	000	+.002	-.002	-.004
868	Italia, Fla.	30/37.0	81/43.1	+.013	+.012	+.004	+.006	+.002	000
92	Fernandina, Fla.	30/40.2	81/27.7	+.024	+.023	+.014	+.016	+.012	+.010
	Profile #4								
161	Cedar Keys, Fla.	29/08.3	83/02.1	-.008	-.009	-.019	-.016	-.021	-.023
870	York, Fla.	29/09.1	82/18.0	-.008	-.011	-.020	-.017	-.022	-.025
495	Ocala, Fla.	29/11.9	82/08.1	000	-.004		-.010	-.017	-.019
	Profile #5								
695	St. Petersburg, Fla.	27/48.9	82/40.2	+.025	+.024		+.014	+.009	+.006
694	Port Tampa, Fla.	27/51.6	82/31.7	+.020	+.020		+.011	+.005	+.003
692	Riverview, Fla.	27/52.4	82/20.4	+.018	+.017		+.010	+.004	+.001
697	Homeland, Fla.	27/50.5	81/49.5	+.021	+.017		+.010	+.003	000
492	Babson Park	27/30.6	81/31.7	+.006	+.001		-.007	-.015	-.017
	Profile #6								
3	Punta Gorda, Fla.	26/56.2	82/03.0	+.025	+.025		+.015	+.008	+.005
480	Ft. Ogden, Fla.	27/06.2	81/56.0	+.007	+.006		-.003	-.010	-.013
484	State Hwy.#8, Fla.	27/12.7	81/39.7	+.016	+.014		+.005	-.002	-.005
483	State Hwy.#8, Fla.	27/12.8	81/26.7	+.033	+.030		+.020	+.013	+.010
485	State Hwy.#8, Fla.	27/12.0	81/20.0	+.033	+.029		+.019	+.012	+.009
486	State Hwy.#8, Fla.	27/12.8	81/11.7	+.016	+.015		+.005	-.003	-.006
487	Kissimmee R., Fla.	27/14.1	80/59.9	-.014	-.015		-.026	-.033	-.036
458	Okeechobee, Fla.	27/14.1	80/50.1	-.019	-.020		-.032	-.039	-.042
489	E. of Okeechobee, Fla.	27/18.1	80/40.8	-.005	-.007		-.019	-.027	-.030
491	W. of Ft. Pierce, Fla.	27/22.2	80/30.2	+.009	+.008		-.005	-.013	-.017
490	Ft. Pierce, Fla.	27/26.4	80/20.9	+.018	+.017		+.003	-.005	-.008
	Profile #7								
498	Sanibel, Fla.	26/27.2	82/00.9	+.016	+.016		+.005	-.002	-.005
479	E. of Ft. Myers, Fla.	26/35.6	81/44.1	-.015	-.015		-.026	-.033	-.036
507	S. of Labelle, Fla.	26/37.2	81/26.6	+.011	+.010		-.001	-.008	-.011
687	United Naval Stores, Fla	26/46.2	81/14.1	+.031	+.031		+.019	+.012	+.009
685	Clewiston, Fla.	26/45.7	80/54.9	+.034	+.033		+.021	+.015	+.010
684	South Bay, Fla.	26/39.9	80/42.9	+.031	+.030		+.017	+.009	+.006
683	Brown's farm, Fla.	26/33.4	80/30.8	+.034	+.033		+.019	+.011	+.007
681	Platt, Fla.	26/42.4	80/10.7	+.044	+.043		+.025	+.017	+.013
2	W. Palm Beach, Fla.	26/42.8	80/02.8	+.045	+.045		+.026	+.018	+.014
	Profile #8								
499	Naples, Fla.	26/08.5	81/47.5	+.020	+.020		+.009	+.001	-.002
476	Belle Meade, Fla.	26/03.8	81/42.0	+.014	+.014		+.002	-.005	-.008
500	Royal Palm Hammock, Fla.	26/00.0	81/36.0	+.012	+.012		000	-.008	-.011
474	Ochopee, Fla.	25/54.1	81/17.8	-.003	-.003		-.016	-.024	-.027
473	Tamiami Trail, Fla.	25/52.0	81/05.6	-.003	-.005		-.016	-.025	-.028
502	Tamiami Trail, Fla.	25/51.0	80/56.8	+.005	+.005		-.009	-.017	-.021
471	Tamiami Trail, Fla.	25/47.6	80/52.4	+.014	+.014		000	-.009	-.012
470	Tamiami Trail, Fla.	25/45.9	80/42.0	+.018	+.018		+.003	-.006	-.009
468	Tamiami Trail, Fla.	25/46.2	80/31.3	+.026	+.026		+.010	+.001	-.002
469	Coral Gables, Fla.	25/46.0	80/18.0	+.025	+.025		+.006	-.003	-.006

Table 1 is abridged from reports of the United Stated Coast and Geodetic Survey.[2] It shows the name, number, latitude and longitude, and the several gravity anomalies for each station expressed in gals. These anomalies are called "Free Air", "Bouguer" and "Isostatic."

The "Free Air" anomalies are arrived at by taking the theoretical value at sea level for the latitude of the station, correcting for the elevation of the station, and subtracting this value from the observed value of gravity at that point. This method takes no account of the effects of topography or of isostatic compensation. From a different point of view it may be said that these two effects balance exactly. The Bouguer anomaly is computed by correcting not only for latitude and elevation but also for the effect of topography within a radius of 103.6 miles. Isostasy is not taken into account in these computations.

The isostatic anomalies given in the last four columns are computed by the Hayford-Bowie formula[3] and are corrected to "depths of compensation" of 56.9 kilometers, 96 kilometers, and 113.7 kilometers. An "indirect" anomaly is also listed for some of the stations. This takes account of the effect of the matter included between the spheroid and the isostatic geoid and of its compensation, in addition to the ordinary effects of topography and isostasy. The profiles are drawn on the anomalies computed for a depth of isostatic compensation of 113.7 kilometers, expressed in milligals.

The conception of isostasy is accepted in the earth sciences but may be restated here. The earth is composed of heterogeneous material which, due to the influence of gravity and its own rotation, tends to become an ellipsoid of revolution. But since the material does not act as a perfect fluid, at least near the surface, the actual surface of the earth is characterized by bulges where the density is deficient and hollows where the density is excessive. These features furnish the mountains, continents and oceans of the earth's surface, the continents floated because of their comparatively light material, the oceans depressed because of the dense material by which they are underlaid. By this theory each columnar unit of the earth has approximately the same mass, whether such unit is in ocean, continent or mountain regions. Such units are conceived as having a radius of not less than

[2]"Principal Facts for Gravity Stations in the United States"
Part 1 (Stations 1-457 inc.)
Part 2 (Stations 458-586 inc.)
Part 3 (Stations 587-713 inc.)
Revised Data for Parts 1, 2 and 3
Part 4 (Stations 714-925 inc.)
Part 5 (Stations 926-1081 inc.)
Department of Commerce, U. S. Coast and Geodetic Survey, Washington, D. C.

[3]See U. S. Coast and Geodetic Survey Special Bulletins No. 10, 40 and 99.

10 kilometers. In the actual reductions much smaller areas than this are taken near the station, but Bowie considered the 10 kilometer radius as the probable average size of topographic masses independently in equilibrium. Such a condition of approximate equilibrium is known as "isostasy" and adjustment to the condition is known as "isostatic adjustment." The compensation of the excess of matter at the surface by the density deficiency below in the continental areas, and of the surface deficiency of matter over the excess density below in the oceanic regions is called the "isostatic compensation" and the depth at which compensation is complete is called the "depth of compensation." For the purposes of comparison, this depth of compensation is shown in Table 1 as at 56.9 kilometers, 96 kilometers, or 113.7 kilometers. The isostatic anomalies used in the profiles are based on the 113.7 kilometer depth of compensation.

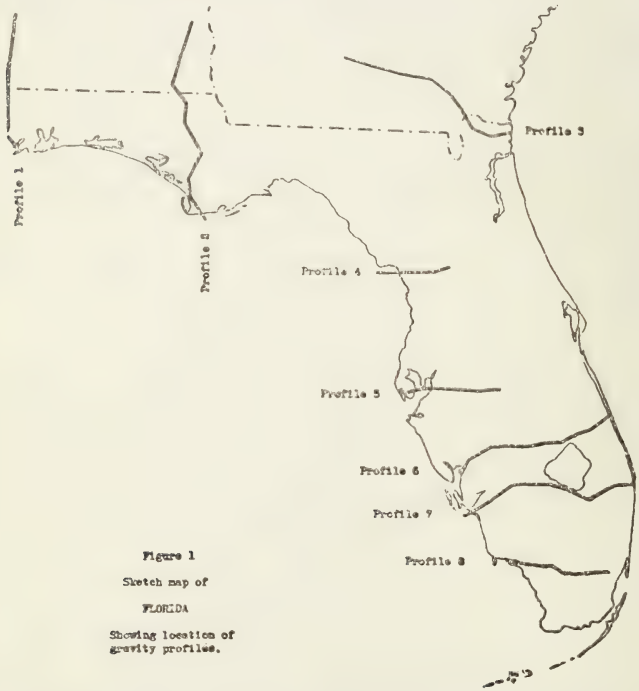
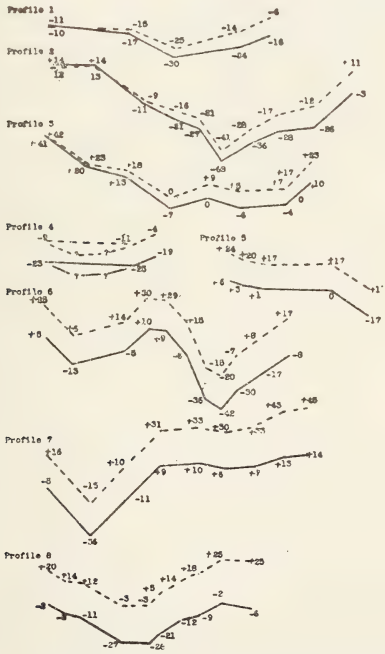


Figure 1
Sketch map of
FLORIDA
Showing location of gravity profiles.

In Profile Number 1, from Capell, Alabama, to Pensacola, Florida, the gravity values decrease as far as Robinsonville, Alabama (—30 mgals), rise to —24 mgals at Muscogee, a distance of something over thirty miles, then in the fifteen miles to Pensacola the value rises to —16 mgals. Though geological information on which to map structure

is scarce the dip in this area seems to be south-southwest at a rate of thirty feet per mile.

Profile Number 2, drawn from Eufala, Alabama, to Appalachicola, Florida, shows a flattening for the first ten miles with a value of +14 mgals, followed by a decrease in the next seventy miles to Sink Creek, Florida, where the value is —48 mgals, then rises coastward until at Appalachicola the value is —3 mgals. There are no well logs on which to map geologic structure along the line of this profile but a well northeast of Marianna started drilling below the top of the Eocene at an elevation of 124 feet above sea level and the water well at Port St. Joe had not reached the Eocene when completed at a total depth of 1035 feet. These wells are about fifty miles apart so the dip along this profile may be assumed to be southward not less than 23 feet per mile.



Profile Number 3 extends from Tifton, Georgia, to Fernandina, Florida. Although values west of Tifton are quite low, at Tifton the anomaly is +41 mgals, decreasing irregularly to —6 mgals at Folkston, from there rising gradually to 0 mgals at Italia, Florida, then at a higher rate to +10 mgals at Fernandina. On Prettyman and Cave's struc-

tural map on top of the Ocala[4] the datum at Tifton is +150 feet while at Fernandina it is —500 feet.

Profile Number 4 is based on three stations only but is here included to show a possible marginal gravity trough. The stations are at Cedar Keys, with a gravity value of —23 mgals, at York with —25 mgals, and at Ocala with —19 mgals. The trend of the profile between Ocala and York suggests that the decrease in value continues further west than York and rises again to Cedar Keys. On the other hand it is possible that there is but little variation in the gravity anomalies between York and Cedar Keys and that this line represents the structural strike. Though we do not know the exact top of the Upper Cretaceous in the York well, it is identified in the Cosden well 10 miles to the north. From the Cosden well to the well now drilling at Cedar Keys there is a difference of datum of 300 feet or only between 6 and 7 feet per mile.

Profile Number 5 extends only about half way across the peninsula but also shows the rise in gravity toward the west coast. There is only one station on the east coast to which this profile might be extended but the gravity locations are considered too few for the drawing of such a profile. It is interesting to note however that the —5 mgal value of that station, at Titusville, is relatively high.

The remaining three profiles are based on more gravity readings but are open to the objection that, especially on the west coast, the line of reading is not strictly along the plane of the section. Profile Number 6 is from Punta Gorda to Fort Pierce, which shows rises in gravity values at both east and west coasts, though a high maximum appears midway across the peninsula. Profile Number 7 from Sanibel to West Palm Beach shows a deep trough on the west side of the peninsula with a plateau on the Atlantic side but at each end the gravity values rise. Profile Number 8 shows a depressed profile with the relatively high areas at each coast, at Naples and Coral Gables.

Other data not included in the table show much the same picture. There are a number of stations between West Palm Beach and Miami and all have relatively high readings. If a profile were drawn from Miami southwestward through Perrine, Homestead and the southwest corner of Dade County and across to the vicinity of Key West it would have the same depressed shape as those in the figures. It may be noted that from Homestead to Key Largo the isostatic anomaly rises from —40 mgals to —17 mgals and from Royal Palm State Park

[4]T. M. Prettyman and H. S. Cave, "Petroleum and Natural Gas Possibilities in Georgia," *Geological Survey of Georgia, Bulletin No.* 40 (1923).

to another station on Key Largo the values rise from —23 mgals to —15 mgals.

No contour map on these values of the state has been drawn for this paper because there are still extensive areas without sufficient gravity control. Unfortunately in south Florida where most of the readings have been made, there are not enough well data on which to draw satisfactory structure maps for comparison with a gravity map.

The same conditions exist in other parts of the country. In the Gulf Coast of Texas and Louisiana in the Houston-Jennings region, Barton, Ritz and Hickey[5] postulated a Gulf Coast Geosyncline comparable with the Appalachian Geosyncline. This the writers based on both geologic and geophysical data but the geologic data seems only to have been used to demonstrate the gulfward dip of the strata and to indicate their observed and estimated thickness. The northward dip of the geosyncline is based on the variation of gravity. The major part of the gravity data used was based on pendulum stations of the United States Coast and Geodetic Survey and a map of a submarine gravity profile of the Gulf of Mexico by Vening Meinesz. Four possible explanations were offered for this gravity axial position:

(1) a geosyncline on the surface of a basement homogeneous in character horizontally from the center of the Gulf of Mexico to the center of the continent,

(2) a gulfward regional dip of the surface of the basement in the Gulf Coast plus a progressive change in the character of the basement from a granitic composition under the Gulf of Mexico,

(3) a geosyncline on the basement in the Gulf Coast plus that progressive gulfward change in the character of the basement,

(4) Barton himself suggested that the gravity minimum might be wholly the effect of the buried salt but abandoned the idea because it did not then seem plausible.

Of the above possible explanations for the gravity minimum in that area the authors chose the third as probably beng the correct one. The interest this "Gulf Coast Geosyncline" has for the present paper is that the gravity picture is quite similar to that of Florida but the geologic information here is not such as to justify the assumption of geosynclinal conditions since the Jurassic in this state. Though Barton's rejected suggestion that the answer is in the salt effect might

[5]Donald C. Barton, C. H. Ritz, and Maude Hickey, "Gulf Coast Geosyncline," *Bulletin of the American Association of Petroleum Geologists,* Vol. 17, No. 12 (1933) pp. 1446-54, 4 figs.

now be more acceptable to the Texas geophysicists it does not seem applicable to the Florida problem.

A similar gravity trough is reported to lie axially within the shoreline from Corpus Christi, Texas, southward[6]. No explanation for this has yet been published. The dip of the beds in this area as mapped on the *Heterostegina* horizon of the Oligocene is eastward to the Gulf of Mexico.

About a year ago Woollard[7] showed that somewhat similar gravity conditions obtain in both New Jersey and Virginia. On one west-east profile for each of these states based on both deep well and seismic data, the gravity values decrease with the structure until the edge of the continental shelf is neared when the gravity suddenly increases in value. Woollard gives three possible explanations for this:

(1) That there exists an actual down-warped section of the crust resulting either from compressional forces or the load of sediments or a combination of these in the continental shelf region.

(2) That the gravity trough represents in part the increased thickness of light sediments and in part the eastward thinning of the acidic basement rocks (of the Piedmont) toward the continental shelf.

(3) The third possibility would be that the trough represents a condition similar to that set forth in the first explanation only differing by being an inherited effect from perhaps Paleozoic time rather than a contemporaneous phenomenon.

As a further contribution to explanations for gravity anomalies mention should be made of a recent paper by Johnston[8] where he gives computations which, as he says, "serve only to show that the positive isostatic anomalies along the Sacramento-Reno (California-Nevada) section are of the order that accords with assumptions regarding subsurface geology that are in general agreement with what we can actually see at the surface." In his cross section he pointed out that gravity readings in Jurassic and Carboniferous sedimentary areas, whose density is 2.55, are positive, averaging +10 mgals, while in the granodiorite area, density 2.73, the values of the stations occupied av-

[6]John F. Imle, Petty Geophysical Engineering Company, Personal communication, September 25, 1940.

[7]George P. Woollard, "The Geological Significance of Gravity Investigations in Virginia," *American Geophysical Union Transactions, Part III* (1939) pp. 317-23.

[8]W. D. Johnston, Jr., "Gravity Section Across the Sierra Nevada," *Bulletin of the Geological Society of America,* Vol. 51 (1940) pp. 1391-96, 2 figs.

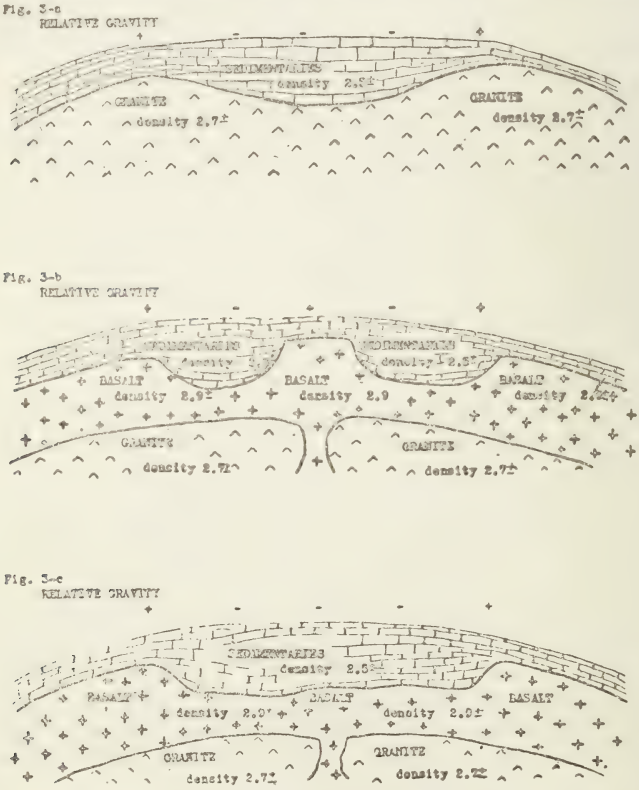
erages —27.5 The interpretation is that the positive values reflect subsurface gabbro which has a density of 2.95. Gabbro is known to occur in the area, in fact at Colfax where the highest value, +16 mgals, occurs, the station lies half a mile south of a gabbro area eight square miles in extent. The explanation seems adequate except that the cross section shows an apparently large area of gabbro exposed at the surface at Yuba Pass on which the gravity reading is only -4 mgals. Johnston's cross section shows that the free air anomaly has a high value here but he attributes it to the relation with topographic relief.

Woollard and the authors of the Gulf Coast Geosyncline agree in an explanation that a combination of thick sediments and increased density of basement sediments have influenced the gravity as observed. Woollard adds a further suggestion that it may be an inherited effect from possibly Paleozoic time. There remains also the suggestion that, as far as the Gulf Coast is concerned, it may only be the effect of the salt known to underlie the area.

It is of course possible that explanations for these coastal gravity troughs may be as numerous as the areas where they are mapped, but the fact that the entire Gulf Coastal Plain and much of the Atlantic Coastal Plain is characterized by an almost continuous gravity trough axial to the coastline spurs the search for a common explanation. In Florida the presence of sediments either as a depressing load or merely as a segment of lighter rocks might be a factor in Profiles 1, 2 and 3, but would not be expected to be a factor in peninsular Florida where practically all sediments since the beginning of the Teritary are free of clastic matter. Whatever sediments were laid down at that time were precipitated from the sea water and would have no relation to a shoreline, except insofar as depth of water was a factor. In the southern part of the peninsula this is true to about the bottom of the Middle Cretaceous. It is not probable that any sedimentary load is a factor in the structure of the Florida peninsula.

The several authors also consider that gravity profiles may be affected by a decrease of acid rocks from the continental layers to basic rocks in the Atlantic or Gulf areas. If this were true it might be a factor in the Florida gravities for Profiles 1, 2, 3, and for the east ends of 6, 7, and 8 but it could scarcely apply to those readings on the west coast of the peninsula. Florida as a structural feature extends 100 miles to the west of the present coast so that in this area the gravity trough is marginal to today's western shoreline but not to the western side of the peninsula as a structure. Furthermore such an explanation is founded on a conception that the earth is composed of two grand

continental segments and two grand oceanic segments, but in a recent book Gutenberg[9] concludes his chapter on the structure of the crust with the statement that "All evidence agrees in dividing the surface of the earth into two areas which are characterized by different structures. The first of these includes the Pacific basin, possibly with a few outlying regions, one of which is in the Arctic basin. The second comprises the remainder of the surface, with the present continents and continental seas, the Atlantic and Indian Oceans and possibly isolated patches within the borders of the Pacific area." He further says, "Gravity observations are consistent with the general description of structures thus far outlined. Where the requirements of isostasy are fulfilled (which is usually the case), the observed gravity is consistent with the continental structure as described above. Where there are large departures from isostasy (large gravity anomalies), there is usually high



[9]Beno Gutenberg, *Internal Constitution of the Earth. Physicis of the Earth VII,* New York: (McGraw-Hill Book Company, 1939) p. 320 and p. 324.

seismicity and other evidence of recent tectonic activity." If Gutenberg's idea prevails any hypothesis founded on the basaltic floor of the Atlantic is open to criticism.[10]

It does not seem that there is any close connection between gravity and superficial structure in the Florida region. Though it may be considered that high gravity anomalies indicate the underground presence of rocks of greater density, it seems that any postulates of seaward change from acidic to basaltic rocks cannot enter into the explanation. A possible explanation is that the pre-Cambrian basement of Florida is composed of rocks of different densities arranged more or less linearly, with those of greater density paralleling and beyond the present shoreline. This might be brought about in several ways:

(1) that the Florida area has been an area of deposition of lighter sediments on a crystalline basement and later slightly raised into a geanticline as in Figure 3-a. This might have occurred at the time of the Appalachian orogeny,

(2) basaltic rocks may have been intruded over a plan of acidic rocks, then subsequently arched and eroded, as illustrated in Figure 3-b.

Our knowledge of the underlying rocks is comprised of recognition of undoubted granite in Pierce County, Georgia, unquestioned basic rocks from a well in Nassau County, Florida, and the questionable occurrence of granite in Lake County, Florida. Though too much importance may not be given to it, it is well to call attention to the fact that the Nassau County well showing the basic rock (at 4817 feet) is near a gravity station whose isostatic anomaly is —4 and the reported granite in the Lake County well (at 6112 feet) is near stations reading —13 and —21. It should also be noted that the basic rock occurrence is near the coast while the reported granite is near the center of the peninsula.

It is possible that the largest gravity anomalies in Florida, as much as —48 mgals, may represent a lag in isostatic adjustment from recent tectonics in the Caribbean region. Woollard's suggestion that it

[10]These conclusions of Dr. Gutenberg are not entirely in agreement with those of James T. Wilson in his article, "The Lone Waves of the South Atlantic Earthquake of August 28, 1933," *Bull. Seis. Soc. of America,* Vol. 30, No. 3 (July, 1940) pp. 273-301. On page 301 of this article is the statement, "The crustal structure of the Atlantic Ocean region is very similar to that of the Indian and Pacific regions, and is characterized by having material with a high velocity for shear waves much nearer the surface than is observed in the continental regions." A small number of seismic records from a new station in the Bermudas seem to agree with this conclusion. But we must wait until there is some agreement on this subject before explaining our Florida profiles in terms of this condition.

may represent an isostatic heritage dating from Paleozoic does not seem appropriate for the Florida area.

It is recommended that this problem be formally called to the attention of the United States Coast and Geodetic Survey by the Florida Academy of Sciences with the request for the establishment of more stations in Florida, especially along the east coast from Jacksonville to Fort Pierce and along the west coast from Appalachicola to Fort Myers. On the results of this several profiles should be made perpendicular to the coast possibly along U. S. Highways 90 (Jacksonville west), and 192 (Melbourne to Orlando), State Highways 30 and 79 (Vero Beach to Clearwater), 19, 16 and 16a (Ormond Beach to Cedar Keys) and and 220 (Arcadia to Sarasota). Such profiles would establish whether the so-called troughs are continuous around Florida's coast as the data now available indicate.

In the preparation of this paper the writer has been in correspondence with a number of persons interested in the problem who have made valuable suggestions and criticisms. Included in this are C. W. Swick, chief of the section of gravity and astronomy for the Coast and Geodetic Survey, J. E. LaRue, geophysicist with the Humble Oil and Refining Company, J. F. Imle, of the Petty Geophysical Engineering Company, Max W. Ball, consulting geologist with Abasand Oils Limited, and F. B. Plummer, geologist of the University of Texas. The writer wishes to acknowledge with thanks their interest and helpful suggestions in the final draft of this paper.

CHEMICAL SEASONING OF LUMBER

H. S. Newins
University of Florida

The art of seasoning of lumber has necessarily been known to artisans of wood since time immemorial, else we could not have referenence today to Noah's Ark and to the clear heart cypress mummy cases which the Egyptians used many centuries ago and such as are now found in museums all over the world. Not that our subject implies durability alone, but rather that the discussion has to do with the seasoning or conditioning of lumber from the green stage as cut in the living tree to the seasoned or dry condition. The Japanese are recorded[1] as having used submergence of timbers in a mixture of six parts sea water and one part fresh water for two to five years to partially condition refractory species and in this manner they may be said to have used chemical seasoning, but the subject of this paper has reference to the more specific application of chemicals to wood in order to reduce any seasoning degrade. In this sense, chemical seasoning of lumber is most recent in its researches! The United States Forest Products Laboratory at Madison, Wisconsin, was the first to enter the field with the resultant studies published by W. K. Loughborough in 1936[2] and 1937[3]. These studies were followed by the investigations of the West Coast Lumber Manufacturers' Association as published by Nelson[4] in 1939, and by the researches of certain chemical companies[5]. Beginning in April, 1937, the Burton-Swartz Cypress Company of Florida at Perry, Florida, and the School of Forestry at the University of Florida undertook some field studies at the yard of this company, and this paper deals with these experiments. The discussion is confined to the air-conditioning of urea-treated tidewater red cypress (including *Taxodium distichum* and *T. ascendens*). Later papers deal with other species and also with the practice of kiln drying of chemically treated wood. Most of the discussions heretofore have dealt with douglas fir and hemlock of the west coast, and we are

[1]H. D. Tiemann, *The Kiln Drying of Lumber* (Philadelphia: J. B. Lippincott Company, 1917), p. 110.

[2]Loughbrough, W. K., "Chemical Seasoning Douglas Fir," *The Timberman,* Vo. 39, No. 4.

[3]Loughbroough, W. K., *Chemical Seasoning of Douglas Fir* (Seattle, Wash.: West Coast Lumberman's Association.)

[4]L. A. Nelson, "Urea As An Aid in Seasoning Douglas Fir," *Chemical Seasoning* (Prog. Report No. 2; Seattle: West Coast Lumberman's Association.)

[5]E. I. du Pont de Nemours and Company, Inc., Wilmington, Delaware.

happy to present here the results of these researches dealing with a southern wood of much commercial significance.

The Burton-Swartz Cypress Company of Florida, host company to these field studies, is one of the largest cypress companies in the world, and carries in the yard an average stock of 35-40 million board feet of lumber. Therefore, any theories of the school laboratory have been well tested in the practical sense by this yard study.

At the outset, it is necessary to point out certain characteristics and precepts dealing with this discussion. All wood is hygroscopic and has a fiber saturation point of 20 to 30 per cent (based on dry weight). Moisture retained in wood beyond 30 per cent must then be free water within the cell cavities and interspaces in excess of the moisture in the minute particles which make up the cell wall. Therefore, wood in the living tree containing a green moisture content of such extremes as 250 percent as in some redwood butts, or like douglas fir with a green moisture content of only 40 percent, must necessarily contain some moisture in excess of the fiber saturation point. This complexity of moisture content adds greatly to the problem, but the real difficulty in seasoning untreated wood is that in even so small a product as a toothpick, the surface fibers in drying will give off moisture in advance of the innermost fibers and will thereby cause an attempt at shrinkage on the surface which is resisted by the less dry interior. This condition is, of course, greatly magnified when the size is increased to, let us say, 4 inch cypress tank stock. This situation in wood is referred to as "internal stress," and when aggravated as in the larger timbers, creates at first a severe tension among the surface fibers, thereby causing a corresponding compression stress within the core of the stick, but later these stresses are reversed because the core upon drying more slowly produces excessive shrinkage, causing the surface to be in compression and the core in tension. The lantern slides which have been prepared to accompany this paper will illustrate the phenomenon.

These internal stresses which are set up in untreated wood when the wood is drying from the green or unconditioned stage to the dry stage are so severe as to entirely disrupt the core or interior of some timbers and render them useless for any purposes requiring much strength. In many cases the stresses may not be enough to rupture the fiber but are sufficient to "bind the saw" in the kerf when an attempt is made to work such wood into useful products. Such a concealed defect is called casehardening and the more serious type of defect just referred to above where the core of the stock is disrupted is called "honey comb" or "hollow-horn."

In all these hypothetical cases the wood has a more or less even moisture distribution and is apparently seasoned, but for years may harbor these internal stresses just like a tightly wound clock spring could hold its tension until released many years later. Thus, improperly dried wood may be severely ruptured by internal stresses or may show no visible signs of these stresses and yet become unshapely when sawed into products. In either case, the stress can be permanent and is a decided deterrent to otherwise good lumber. (The writer well recalls a manufacturer of office furniture who had thousands of stool tops stored away, waiting the time when his operators could bore the four necessary holes in the stool top for the legs without causing the holes to crack open on the edge grain, but he did not know then that the wood was casehardened, and, like the wound clock spring, would hold this tension indefinitely unless relieved by some agency such as, unfortunately in his case, the removal of the hole plug.) These severe internal stresses are not necessary and can be relieved by the proper methods of drying whether by the open air yard method or by the dry kiln method.

The method heretofore used in relieving these internal stresses has been to dry the lumber in an atmosphere of higher relative humidity such as can be controlled in a dry kiln or in the case of yard drying by closer piling in covered piles or under sheds. This method is entirely satisfactory but can well be supplemented by the use of chemical seasoning for both the dry kiln and seasoning yard in the case of more exacting needs of wood such as for war time uses and such products as tank stock. The drying of untreated wood has necessarily required a moisture gradient of gradual increase from the shell of the lumber stock to the interior core, and the lumber has therefore been dried "from outside in." Now, however, through the researches reviewed in this paper, it is possible to accomplish the equivalent of a higher relative humidity in the atmosphere immediately in contact with the surface fibers of the lumber to be air dried or kiln dried. This is accomplished by saturating these surface fibers of the wood with water soluble hygroscopic chemical, which chemical has a lower vapor pressure than the hygroscopic water deeper within the wood. In this manner, a vapor pressure gradient is established increasing from the shell to the core of the lumber stock because the chemical as it diffuses into the wet wood is in greatest concentration at the surface fibers. Thus chemically treated wood of this character will dry from "inside out" because of the higher vapor pressure from within the lumber, and will thereby reduce the internal stresses already referred to above.

A list of some of these water-soluble hygroscopic chemicals with their respective vapor pressures follows:

TABLE 1*

Saturated aqueous solution of —	Relative vapor pressure of the air over the solution at 68°F.
Calcium chloride	0.32
Magnesium chloride	.32
Calcium nitrate	.59
Ammonium nitrite	.68
Sodium nitrate	.76
Sodium chloride	.78
Urea	.80
Ammonium sulfate	.81

*Data from Peck, E. C., *"The Effect of Solutions of Various Chemicals and Mixtures of Chemicals on Relative Humidity, Equlibrium Moisture Content of Wood on Shrinkage"* (unpublished report).

The original yard tests of tidewater red cypress were made with sodium chloride in order to determine that the principle involved in these theories would be applicable. It was thereby determined that because of the high moisture content of freshly cut cypress and the soft even quality of the wood that cypress could be treated so easily and economically as to make it only necessary to apply the water soluble hygroscopic chemical in crystal form. It is important to note here that these researches indicated a vast difference in the results attained with different species, and that conclusions arrived at here with tidewater red cypress cannot be applied per se to other commercial species.

Having determined upon the success of the principle involved in the application of chemical seasoning to tidewater red cypress, other chemicals were reviewed. Sodium chloride had been exceedingly low in first cost, and therefore satisfactory for *experimental* purposes, but from a practical viewpoint was found to be unsatisfactory because of its corrosiveness and tendency for treated wood products to sweat in an atmospheric relative humidity of 75 percent.

The set of curves in Fig. 1 shows the moisture content of sitka spruce (approximately similar to other woods) at equilibrium with the indicated temperature, partial vapor pressure and relative humidity.

The curves in Fig. 2 are based upon experimental studies made with sodium chloride, and show the equilibrium moisture content of natural wood and wood treated with a saturated solution of this chemical. Both curves are for a temperature of 70°F.

With these two sets of curves, Figs. 1 and 2, it is possible to solve almost any situation which may arise in the air seasoning or dry kiln seasoning of chemically-treated wood.

Invert sugar was observed to be excellent in reducing shrinkage, but was unsatisfactory from a practical viewpoint if for no other rea-

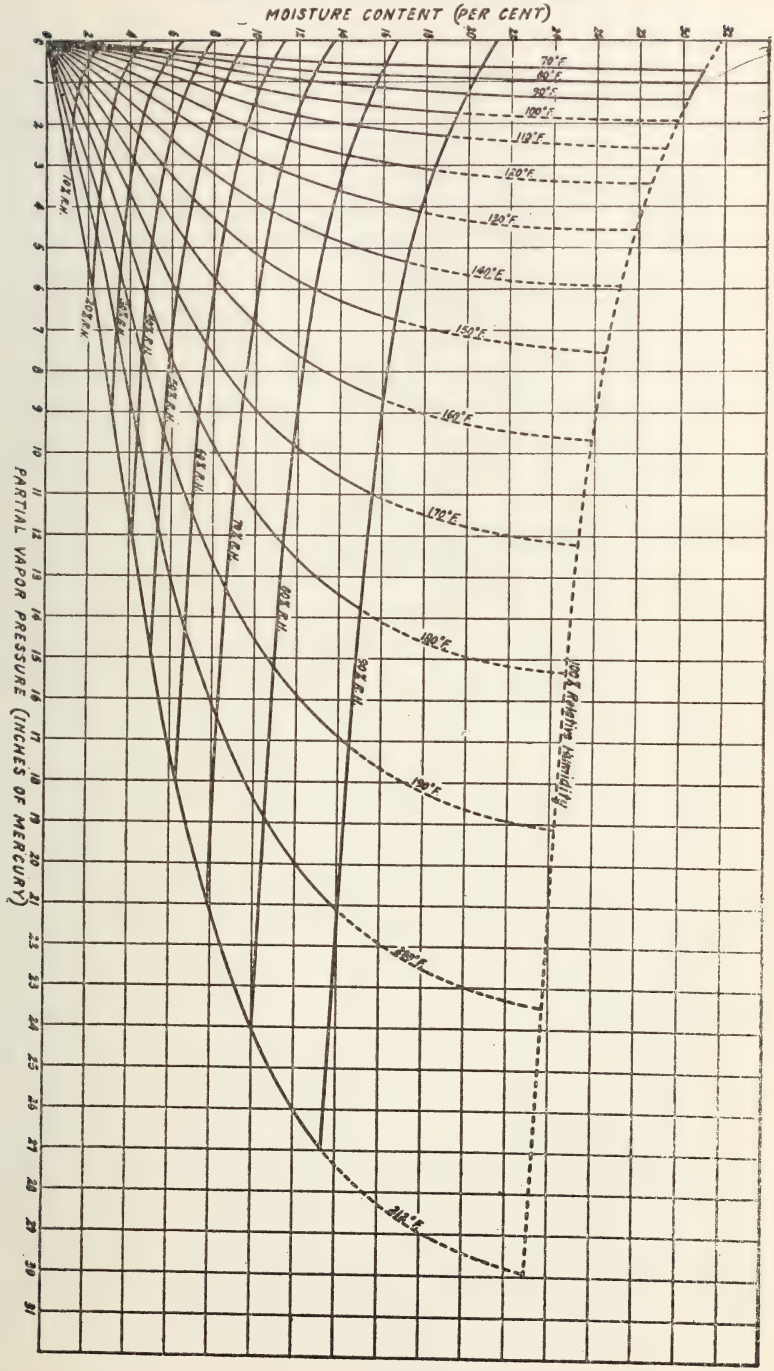

MOISTURE CONTENT (PER CENT)
PARTIAL VAPOR PRESSURE (INCHES OF MERCURY)
70°F
80°F
90°F
100°F
110°F
120°F
130°F
140°F
150°F
160°F
170°F
180°F
190°F
200°F
210°F
100% RELATIVE HUMIDITY
90% R.H.
80% R.H.
70% R.H.
60% R.H.
50% R.H.
40% R.H.
30% R.H.
20% R.H.
10% R.H.

Figure 1.

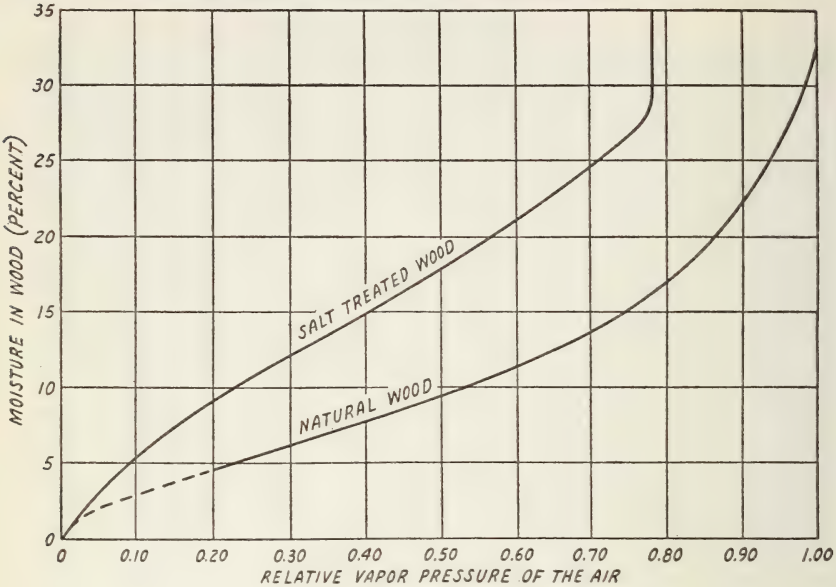


Figure 2.

son than that the chemical attracted insects, and especially bees, which became a yard nuisance during the experiments. Furthermore, the full intishrink value of invert sugar cannot be realized during air seasoning.

Of all the chemicals listed, crystal urea, $(NH_2)_2CO$, was found to have the best chance of wide application because:[6]

1. It effectively reduced seasoning degrade in both air and kiln drying.
2. It is not corrosive to metals used with wood.
3. It does not dull saws and planer knives.
4. It does not cause "sweating" in treated lumber after the drying period, even under conditions of high humidity.
5. It does not promote insect or fungus attack, and has been found inhibitory to certain rot fungi.
6. It has not been found to discolor the woods tested on the yard at normal kiln temperatures.
7. It adds a certain amount of flame retardance to wood.
8. It is non-poisonous and harmless to the skin.
9. It is stable and can be stored indefinitely without deterioration.
10. It is commercially available and low in cost.

Urea is a white odorless crystalline solid, in appearance resembling table sugar and is produced synthetically by reacting ammonia with carbon dioxide at high pressure. It is usually packed in 100 pound 5-ply paper-lined moisture-proof bags, and the price f. o. b.

[6]*Crystal Urea for Chemical Seasoning* (Wilmington, Del.: Ammonia Department, E. I. du Pont de Nemours Co., Inc.).

Atlantic and Gulf ports is $85.00 per ton in minimum lots of 20 tons. Thus, the cost at tidewater red cypress mills located in the vicinity of these ports such as at Perry, Florida, is a minimum of 4½c per pound, or $1.70 per MBM of treated lumber when applied as recommended at the rate of 40 pounds per MBM.

Investigation at Perry, Florida, has indicated that the best method of application was to spread the urea crystals (at the rate of 40 pounds per MBM) along the center line or the center-grain line of flat-grain freshly cut lumber, and the crystals were then diffused sufficiently into the stock. Because of the high moisture content, and even texture of tidewater red cypress mentioned above, it was found not to be necessary to turn the timbers nor to bulk-pile them and the urea crystals would be absorbed within the period of one week, depending upon the size, whether 4/4, 8/4, 12/4 or 16/4 inch stock. Interesting experiments were conducted on end treatments whereby prepared paints were used to protect the ends of some of the lumber, but it was observed that these treatments held the ends too rigidly and created some additional internal stress here, whereas instead of paint an extra handful or two of urea crystals applied along the horizontal surface of the lumber near the edge and followed with 1 inch cleats or strips to cover these ends was satisfactory protection against checking during air drying.

The results of tests made upon urea treated 16/4 inch tidewater red cypress, which was strip-piled in the Burton-Swartz yards in December, 1939, and next examined 10 months later, in September, 1940, showed that the timber which was originally cut green from the saw wit ha moisture content of 160 percent had a moisture content in both cases of approximately the same, namely, 16.6 percent for the untreated, and 15.4 percent for the treated timbers. Both were dried under similar strip-pile conditions, and in adjacent yard piles.

TABLE 2*

Date	Mean Monthly Temperature
December, 1939	61.8
January, 1940	52.0
February, 1940	58.0
March, 1940	64.6
April, 1940	69.4
May, 1940	74.6
June, 1940	81.3
July, 1940	83.2
August, 1940	82.5
September, 1940	78.6

*Data from *Monthly Meteorological Summary,* Weather Bureau, U. S. Department of Agriculture, Tampa, Florida.

The shrinkage percent was normal in both cases, but the stock when inspected showed for the chemically treated lumber a high quality of even-textured wood free from any appreciable internal stress. This was evident not only to the surfaces of the stock, but also to the ends which had been handled, as mentioned above, only with cleats over the chemically treated timber. On the other hand, the average stock taken from the untreated parcel of lumber revealed some degrade from the original F & S or tank stock down to select, shop and number 1 common, respectively. Furthermore, this untreated stock showed evidence of internal stress, and, when tested, by slotting for casehardening, the surface pieces broke apart because of deeply penetrating surface checks.

This contrast in treated and untreated 16/4 inch Tidewater Red cypress shows most strikingly the possible savings in dry spreading urea upon the flat-grain surface of air-seasoned stock, as per Table 3.

TABLE 3

Savings effected by dry spreading urea upon 16/4 inch cypress for air-drying at Burton-Swartz Lumber Company, Perry, Florida.

F.O.B.		Cost of urea per MBM	Labor cost per MBM of spreading urea	Net saving per MBM
F&S or "Tank"	146.25	1.70		.....
Select	102.75	1.70		41.80
Shop	91.75	1.70		52.80
No. 1 Comm.	54.00	1.70		90.55

Thus 16/4 inch tank stock holding first and second grade after urea seasoning has saved $41.80 per MBM over stock, which, when untreated, would have degraded to select; $52.80 over shop grade, and $90.55 over No. 1 common grade.

In handling certain timber species, notably douglas fir, it is necessary to bulk-pile the lumber and in some cases to turn the timbers in orde rto obtain a satisfactory application of crystal urea. However, in treating tidewater red cypress tank otsck, it is only necessary to apply the Urea as the lumber is strip-piled, and, therefore, there is no additional labor cost other than the application of the urea, which takes place immediately and only as the parcel of lumber is piled. The zones of penetration are the basis of the safer drying accomplished, and vary from saturation at the outermost wood fibers to less and less amounts toward the core of the stock. (Interesting experiments were conducted by the writer upon sawmill green blocks of sap pound cypress poles submerged in a bag of crystal urea for a few days, and later removed for air drying. The vapor pressure at the core of these small blocks immediately was exerted

to such an extent that crystals were formed like icicles and stalactites during the first twenty-four hours of drying, and thereafter. These crystal formations were excellent evidence of the released vapor pressure from within which had permitted the drying to progress without surface checking the blocks. In other words, to review again this phenomenon, the high concentration of urea at the periphery of the blocks had sufficiently reduced the vapor pressure so that drying at the surface could not start until the inside had first dried.)

Flame retardant tests upon urea-treated wood have been made at the United States Forest Products Laboratory and at the laboratory of one of the large chemical companies. The Forest Products Laboratories determined from fire-tube data that with the exception of the nitrates, the salts are, to some degree, fire retardants[9]. The chemical company laboratory reports of flame retardant action show that urea-treated wood is appreciably less inflamable than untreated wood. The one test shows that by a modified New York Building Code crib test for "fire-proofed" wood, the duration of the flame after removal of the burner was determined, and the results are as follows:

TABLE 4*

Fire Retardant	Concentration	Duration of Flame
Urea	39.5%	No flame
Urea	3.5	60 secs.
Untreated	-	100 secs.

*Letter from Mr. J. F. Berliner, Ammonia Department, E. I. du Pont de Nemours & Company, Inc., Wilmington, Delaware, May 3, 1940, p. 1.

The Department of Forest Pathology at the University of Florida School of Forestry now has under way a series of tests of the fungicidal properties of urea-treated wood. The U. S. Forest Products Laboratory reports that in the concentration used in chemical seasoning, most of the salts are somewhat decay resistant for a while, and they note the presence of urea as no handicap to use in toxicity.

Tests of toxicity of the chemical company referred to above indicated that concentrations of Urea as low as 0.2 percent are completely inhibitory for all practical purposes and that at no concentration does urea stimulate growth of wood rotting organisms,[8] and also showed that urea treatment of wood did not stimulate attack by termites and that such wood may be more resistant than untreated wood. Termite tests are now also in the ground at the Austin Cary Memorial Demonstra-

[7]W. K. Loughborough, *A Primer on the Chemical Seasoning of Douglas Fir Status November, 1938* (Madison, Wisconsin: U. S. Forest Products Laboratory), chart opp. p. 10.

[8]*Ibid.*, p. 4.

tion Forest of the School of Forestry, and thus far show no infestation nor is there any likelihood that the treated cypress samples will encourage termites to attack.

(The drying of urea-treated tidewater red cypress is found to be perhaps the easiest of all commercial woods, and yet like so many easy things, is fraught with real cautions. Urea will apparently perform miracles in the seasoning of wood, but this does not mean that the drying can proceed without scientific and expert supervision. Tidewater red cypress is a very valuable wood and is known throughout all lumber markets of the world as the "Wood Eternal." The bulk of the last remaining stand of this renowned timber is in Florida. Any savings which can be effected in the seasoning process means just exactly that much more conservation of this timber resource. And strangely enough, although cypress is so soft and even-textured, it is really most exacting in ordinary air drying and kiln drying treatment; and another interesting fact is that, although the wood is so durable as to be called "Wood Eternal", and therefore does not require impregnation with preservatives, nevertheless, if pressure treatments were necessary, it would be found that because of its peculiar lamella cell structure,[9] the wood is one of the most refractory to treat.)

Corrosion tests are necessary on chemically-treated wood because the cells of the treated wood have imbibed whatever corrosiveness may be inherent to the chemical used. Thus, any tank stock treated with sodium chloride will in due time corrode ferrous fastenings and hoops, and if used in a relative humidity exceeding the vapor pressure of the salt (75 percent) will drip salty water on any adjacent factory metal parts. The University of Florida is conducting a series of corrosive tests in which the treated boards are exposed to the atmospheric elements at the University Demonstration Forest for a period of six months. The treated boards have been soaked 72 hours in respective chemicals, including a 50 percent urea solution, and these boards have been allowed to air dry several days before placing them in the test. Nails and screws of various metals were driven into the boards and metal strips were tied on by cord.

Similar tests carried on by a chemical company show the following results: (Table 5 on next page).

The U. S. Forest Products Laboratory, after a careful study of corrosiveness, finds that of all the chemicals employed for this treatment of wood, urea has a very extended use and the presence of this chemical in wood has practically no handicap.

[9]George M. Hunt and George A. Garratt, *Wood Preservation* (New York: McGraw-Hill Book Company, Inc., 1938), p. 229.

TABLE 5*

	% Weight Change per Year Wood Treatment		
Metal	*Sodium Chloride*	*Urea*	*Untreated*
17S Aluminum Screw	— 4.7	— 0.2	— 0.3
Brass Screw	— 1.5	— 0.6	— 0.6
Chromium Plated Brass Screw	— 0.6	— 0.2	0.0
Copper Nail	— 2.0	— 0.6	— 0.7
Everdur Nail	— 3.3	— 0.5	— 0.8
Galvanized Iron Nail	— 3.7	— 0.8	— 0.4
Lead Strip	— 0.2	— 0.1	— 0.1
Monel Screw	— 1.2	— 0.1	— 0.3
Nickel Plated Iron Screw	— 1.4	— 0.7	— 1.2
18-8 Stainless Steel Screw	— 1.0	0.0	+ 0.1
Steel Nail	— 9.9	— 4.1	— 3.0
Tin Strip	+ 2.4	+ 0.8	+ 0.4
Average†	— 2.7	— 0.7	— 0.7

*Letter from Berliner, May 3, 1940, p. 9.

†In calculating the average, all increases in weight were taken as equivalent decreases in weight.

The results of this laboratory and field study of the application of urea to tidewater red cypress for air seasoning indicate great possibilities for the chemical seasoning of lumber. It has been shown here that savings as great as $90.00 per MBM can be effected, but chemical seasoning requires expert supervision and unless handled scientifically may prove to be a boomerang instead of a bonanza. A careful review of these data should indicate the opportunities in this field for other woods and for the kiln drying of lumber as well as of air seasoning.

THE LIMNOLOGY OF LAKE MIZE, FLORIDA

William J. K. Harkness and E. Lowe Pierce
University of Florida

In moderately deep lakes of temperate regions thermal stratification is a characteristically normal condition. This stratification is well marked in the summer; in the winter, although present under the ice, it is less well defined.

Associated with the thermal stratification there is a stratification of such gases as oxygen and carbon dioxide. Both the thermal and gaseous stratifications have a controlling effect upon the welfare and activities of the inhabitants of the lakes, and so have immense ecological importance, as well as being of much interest in themselves.

From midsummer to fall this stratification divides the water of a lake into three layers: (1) An upper layer, the *epilimnion,* of warm water which is light in weight, and which generally contains a high concentration of dissolved oxygen, and a low concentration of dissolved carbon dioxide. (2) A middle or transition layer, the *thermocline,* in which there is an abrupt temperature change from warm water at the top to cold water at the bottom. (3) A lower layer, the *hypolimnion,* of cold heavier water extending from the lower surface of the thermocline to the bottom of the lake. The water of the hypolimnion generally contains a lower concentration of oxygen and a higher concentration of carbon dioxide than that of the epilimnion.

This condition has been described for many lakes in the north temperate region, and so is expected and anticipated for fairly deep lakes where the winter temperature is freezing or at least quite low and the summer temperature is fairly high.

The state of Florida with its many lakes and its proximity to the tropics and tropical conditions presents exceptionally promising opportunities for the extension of knowledge in the field of temperature and gaseous stratification of the water in lakes.

Most of the Florida lakes are comparatively shallow, and have a relatively large surface area in relation to their depth. This condition is unfavourable to any great degree or stability of stratification. Slight midsummer stratification has been observed by Professor J. Speed Rogers and the senior author, in different years, in Kingsley Lake, Florida, which has a maximum depth of fourteen meters (45.9 feet), by Professor Rogers in Townsend's Sink, Florida, which has a maximum depth of four and one-half meters (14.8 feet), and by Mr. O. L. Meehean in Buck Pond, Ocala National Forest, Florida, with a depth of eight meters (26.25 feet). On July 18, 1940, a temperature series at Lake Mize demonstrated a thermal stratification in which the strata

PLATE 1. Lake Mize, November 9, 1940

were well defined and clearly demarked. The subsequent history of this stratification has been followed.

LAKE MIZE

Lake Mize lies in the Austin Cary Memorial Demonstration Forest, ten miles northeast of Gainesville, Florida, latitude 29° 44′ north, longitude 82° 13′ west, at an elevation of 33 meters (approximately 145 feet) above sea level.

It has a surface area of about 1.2 hectares (3 acres), and is rough-

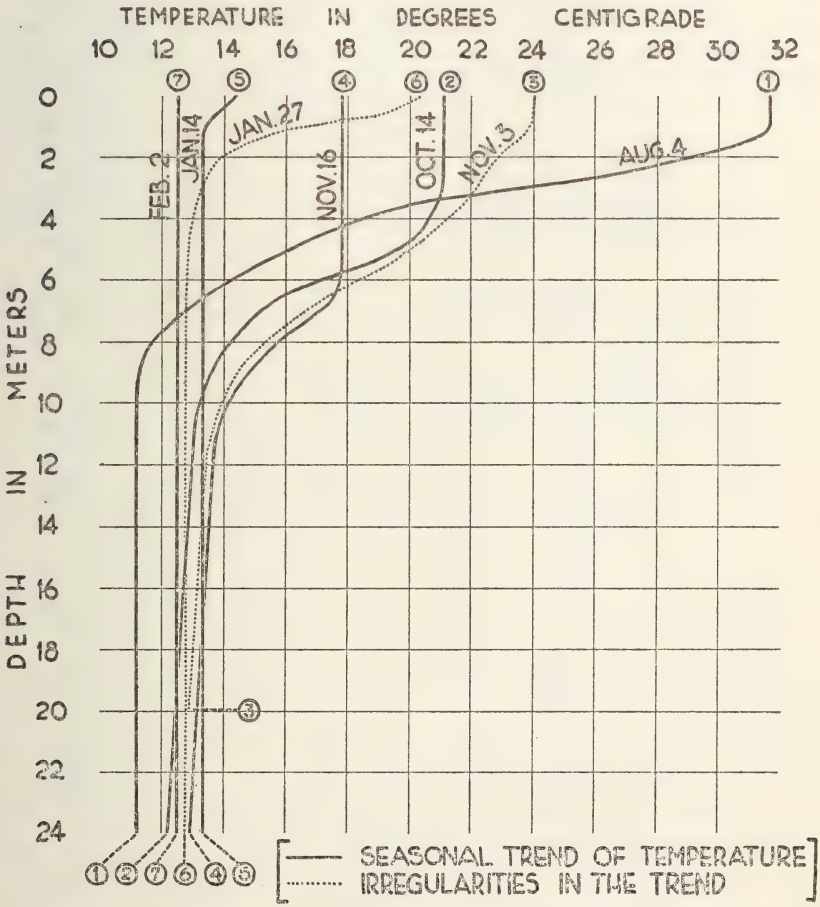


FIGURE 1. CURVES ILLUSTRATING TEMPERATURE RECORDS FOR MIZE LAKE, AUGUST 4, 1940 TO FEBRUARY 2, 1941.

ly circular in outline, except for a small bay projecting out on one side and constituting about one quarter of the total area (Plate 1). This bay is relatively shallow and is partly cut off from the main part of the lake by a sand tongue.

Disregarding the bay, the circular portion of the lake is a typical sink-hole formation, increasing in depth rapidly from the shore, and in a small area near the center reaching a maximum depth of 25 meters (about 82 feet). There is a fairly extensive level bottom at 10 meters, and a small flat ledge at 15 meters from which there is an abrupt drop to the bottom of the deep hole which is relatively small. The bottom of the deep hole is a thick layer of soft oozy mud, that gives off bubbles of gas in profusion when penetrated by the sounding lead. The bottom on the ledge at 15 meters, and the flat bottom at 10 meters appear to be firmer.

The lake lies in a flatwoods, a sandy plain with poor drainage, on which long leaf and slash pine, saw-palmetto and gallberry predominate. About two thirds of the lake is closely bordered by shrubs some of which overhang the water. The predominating shrubs are gall-

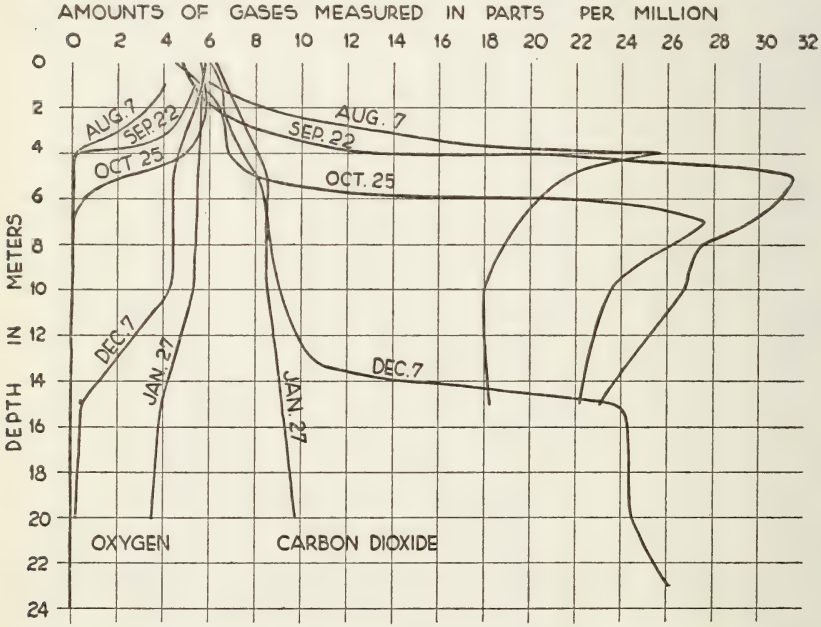


FIGURE 2. CURVES ILLUSTRATING AMOUNTS OF DISSOLVED OXYGEN AND CARBON DIOXIDE IN MIZE LAKE . AUGUST 7, 1940 TO JANUARY 27, 1941.

berry, wax-myrtle and saw-palmetto. The remainder of the shore line is more open and bears a few typical semi-aquatic herbs which are treated more fully in the section dealing with plants.

The lake appears to receive all of its water supply from the surface drainage of about 32 hectares (80 acres) of the adjoining forest. There is no outlet excepting for a temporary stream which carries away the overflow at high water. At suvh times the stream flows southeast emptying into a branch of Hatchet Creek. From September 27 to November 13, 1940, the recorded rainfall at Gainesville was only 2 mm. (0.14 inch), and during this period the surface level of the water fell about one meter. During December, 1940, and January and February, 1941, the rainfall as recorded at Gainesville was 39.34 cm. (15.49 inches) which produced a water level higher than that on July 18 when the investigation began.

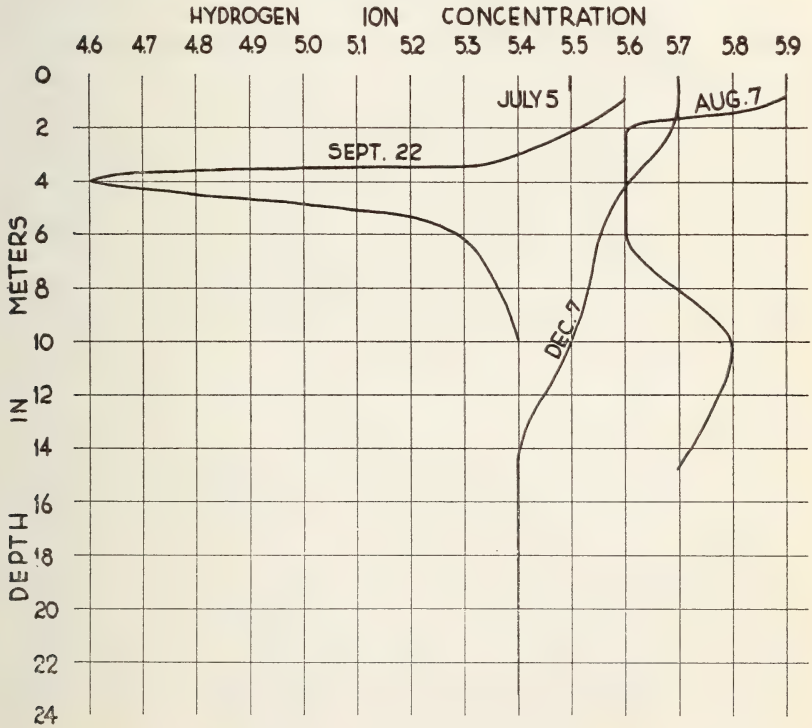


FIGURE 3. HYDROGEN ION CONCENTRATION, BY COLORIMETRIC METHOD. LAKE MIZE. JULY TO DECEMBER, 1940.

METHODS

Temperatures of the water were taken by lowering a recording thermometer to known depths, and after hauling it up reading the recorded temperatures. This gave a series of readings showing the temperatures at regular intervals from the surface to the bottom. Such series were made at fairly regular time intervals from July 18, 1940, to March 2, 1941. A Taylor maximum and minimum registering thermometer, calibrated at two degree intervals in the Fahrenheit scale was used. The readings were corrected by checking the thermometer against one certified by the U. S. Bureau of Standards. All temperatures have been converted into centigrade equivalents, and are given in intervals of one tenth of a degree.

The chemical analyses were made by the junior author in conjunction with his work at the University Conservation Reserve at Welaka, using the excellent facilities available there.

Other members of the staff and graduate students at the Department of Biology, University of Florida, have assisted with various aspects of the study. Our sincere thanks are expressed for the cooperation of the School of Forestry, and in particular to Director H. S. Newins, who made it possible for us to have free access to Lake Mize at all times and who provided the use of a boat for the investigation. Mr. J. R. Watson, Agricultural Experiment Station, University of Florida, made available for our use the meteorological records taken at Gainesville from which the data on air temperatures and precipitation have been compiled. The authors wish to express their personal gratitude to Professor T. H. Hubbell, Acting Head of the Department of Biology, for his advice and assistance which were generously given throughout the course of the work.

RESULTS

Temperature Records:

The series of water temperatures taken from July 18 to March 2, present a clear picture of the stratification of the lake at the date of each series, and also show the trend of the stratification throughout the period.

During midsummer and early fall there was a well established stratification. The epilimnion varied in depth from one to four meters; the thermocline varied in thickness from four to seven meters, with a change in temperature of as much as 37°C. on August 1; and the hypolimnion extended from approximately eight meters to the bottom of the lake.

The cool windy weather of the fall cooled and stirred the surface water so that the epilimnion became cooler and thicker, the thermo-

TABLE 1.
DEPTH AND TEMPERATURE RELATIONS, LAKE MIZE
JULY 18, 1940 TO *MARCH* 2, 1941

DEPTH	Degrees Centigrade on Dates Given																							
	July 18	July 30	Aug 4	Aug 7	Aug 17	Sept 12	Sept 22	Sept 29	Oct. 6	Oct. 13	Oct. 19	Oct. 25	Nov 3	Nov 9	Nov 16	Dec. 1	Dec. 7	Dec. 22	Jan. 14	Jan. 21	Jan. 27	Jan. 31	Feb. 12	Mar. 2
Surface	29.2	29.5	31.7	31.7	31.2	31.2	31.7	24.0	25.6	25.0	21.1	24.8	23.9	19.6	17.8	17.0	18.3	17.8	14.4	14.4	20.3	13.3	12.5	13.3
0.5 M.		29.5	31.7	30.6	31.2	29.0	29.5	24.0									16.1		13.9	14.4	19.5	13.3	12.5	
1.0 M.		29.5	31.7	30.3	30.6	28.4	27.8	24.0	23.9	23.3	21.1	23.3	23.9	19.6	17.8	16.4	15.8	17.2	13.3	13.3	16.4	13.3	12.5	12.8
2.0 M.	26.6	29.1	29.0	29.0	30.1	27.8	27.3	24.0	23.3	22.2	21.1	22.2	22.8	19.6	17.8	16.4	15.6	16.7	13.3	12.8	13.9	13.3	12.5	12.8
3.0 M.	22.3	23.7	24.0	24.0	25.6	27.3	26.4	23.4	22.8	22.2	21.1	21.1	22.2	19.6	17.8	16.4	15.3	16.1	13.3	12.8	13.3	13.3	12.5	12.8
4.0 M.	17.3	18.9	18.4	19.3	19.6	22.3	24.0	23.4	22.2	21.7	20.8	20.8	21.1	19.6	17.8	16.4	15.3	15.6	13.3	12.8	13.1	13.1	12.5	12.8
5.0 M.	15.0	15.6	16.2	17.3	16.7	17.8	19.0	19.3	19.2	20.0	20.0	20.0	20.0	19.6	17.8	16.4	15.3	15.3	13.3	12.8	13.1	12.8	12.5	
6.0 M.		14.0	14.5	15.3	15.1	15.6	16.2	16.2	16.7	17.2	17.2	17.8	18.3	18.3	17.8	16.4	15.3	15.3	13.3	12.8	12.8	12.8	12.5	
7.0 M.	12.8	12.8	12.8		13.7	14.5	15.1	15.1	15.0	15.0	15.6	15.8	16.7	16.3	17.2	16.4	15.3		13.3	12.8	12.8	12.8	12.5	
8.0 M.	12.8	12.8	11.6	12.8	12.8	13.4	14.0	14.0	14.4	14.4	14.4	14.4	15.3	15.0	15.6	16.1	15.3		13.3	12.8	12.8	12.8	12.5	
9.0 M.			11.3			13.1	13.4	13.4	13.6	13.3	13.6	13.9	14.4	14.4	14.7	15.6	15.3		13.3	12.8	12.8	12.8	12.5	
10.0 M.		12.3	11.2	11.9	12.3	12.8	12.8	13.1	13.6	13.3	13.3	13.6	13.9	13.3	14.1	15.0	15.3	15.0	13.3	12.8	12.8	12.8	12.5	12.5
11.0 M.	11.9						12.8		12.8				13.6	13.5	13.9			15.0	13.3	12.8	12.8	12.8	12.5	12.5
12.0 M.														13.4	13.6		15.0	15.0	13.3	12.8	12.8	12.8	12.5	12.5
15.0 M.		11.2	11.2	11.2	11.4	12.3	12.3	12.6	12.8	12.8	12.8	12.8	13.0	13.4		13.9	14.2	15.2	13.3	12.8	12.8	12.8	12.5	12.5
20.0 M.		11.2	11.2		11.4		12.3	12.3	12.2	12.5	12.5	12.5	12.8	12.9	13.2	13.6	13.6	14.4	13.3	12.8	12.8	12.8	12.5	
24.0 M.	11.7	11.2	11.2		11.4	12.3	12.3		12.2		12.2			12.8	12.8	13.1	13.6	13.9	13.3	12.8	12.8	12.8	12.5	

cline less clearly demarked, and the cold water of the hypolimnion warmed slowly.

During December stratification disappeared and the thermocline was destroyed. The temperature in the hypolimnion rose considerably and by January 14 the water of the lake was homothermous. This homothermous condition persisted until March 2, the date of the last series, with the water becoming gradually colder during the winter. The temperature series are given in Table 1, and characteristic series are graphically shown in Figure 1.

The sun warms the land, water and air differentially, but within certain limits the temperature of exposed natural waters is correlated with atmospheric temperatures. The daily air temperatures and the average temperature of the atmosphere over a long period of time affect the temperature of the surface water and to a lesser extent the deep water of a lake. The daily maximum and minimum temperatures from July 1, 1940, to March 31, 1941, are given in Table 2, and the mean monthly temperatures for 1939, 1940 and ture and the wind velocity all have a deciding influence on the tem-

The time of day, the intensity of the sunshine, the air temperature and the wind velocity all have a deciding nifluence on the temperature of the surface and near surface water, and may even affect the temperature of deeper strata. The time and atmospheric conditions when each temperature series was taken are summarily presented.

Dissolved Gases:

Oxygen: In Lake Mize, from midsummer through fall, the dissolved oxygen is confined almost wholly to the epilimnion, the surface stratum of water. As the cooling effects of the late fall weather impose themselves upon the lake, there is a progressively deeper mixing of surface waters with those of the underlying strata, and the dissolved oxygen is carried deeper. By mid-fall the upper portion of the thermocline contains dissolved oxygen in small amounts, but the lower part of the thermocline and the hypolimnion are entirely devoid of dissolved oxygen. With the breaking down of the thermocline in December the dissolved oxygen is carried into deeper water in ever increasing amounts. When the water of the lake finally becomes homothermous the amount of oxygen at twenty meters, the greatest depth from which a sample was taken, was almost at the same concentration as it was in the surface water. These oxygen relations and changes in concentration are shown in Table 4, and are represented graphically in Figure 2.

Carbon Dioxide: The amount of carbon dioxide varies inversely with the amount of oxygen in the epilimnion and thermocline. The

TABLE 2.

DAILY MAXIMUM AND MINIMUM TEMPERATURES IN DEGREES CENTIGRADE FROM JULY 1940, TO MARCH 1941, AT GAINESVILLE, FLORIDA.

	1940										1941							
Date	July		August		September		October		November		December		January		February		March	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
1	30.6	22.2	32.8	22.2	32.8	22.8	27.2	14.4	30.6	18.9	27.8	13.3	24.4	11.1	21.1	6.1	10.6	-2.2
2	31.7	21.7	30.6	21.1	33.3	20.0	28.3	11.7	27.8	18.9	15.6	13.9	25.6	13.9	20.6	10.0	18.3	-2.8
3	32.2	20.6	31.1	22.8	33.3	20.0	28.9	12.2	26.7	12.2	15.6	8.3	22.8	14.4	20.0	13.9	22.2	4.4
4	27.8	21.7	31.1	22.8	32.2	22.2	28.3	13.3	28.3	14.4	17.2	2.2	16.1	8.3	14.4	1.1	23.9	10.0
5	31.7	21.1	33.9	21.7	31.1	21.7	28.9	15.6	28.9	15.6	22.8	1.7	13.9	6.7	17.8	-0.6	16.1	4.4
6	31.7	21.1	33.9	21.1	30.0	20.6	28.3	16.7	28.9	14.4	22.2	6.1	15.0	6.1	14.4	6.7	18.3	6.1
7	30.0	20.0	33.3	21.1	30.0	21.7	29.4	14.4	24.4	10.6	24.4	11.1	10.6	8.9	15.6	11.1	27.2	13.8
8	29.4	21.7	33.3	22.2	27.8	21.1	26.7	15.6	20.0	6.7	21.7	13.3	15.6	3.3	10.6	2.8	16.6	13.8
9	30.6	21.7	33.9	22.2	31.1	20.0	27.2	12.8	23.9	6.1	20.6	6.7	17.2	5.0	10.6	3.3	16.1	5.5
10	32.8	20.6	32.2	21.7	32.8	19.2	26.1	12.2	27.2	11.7	24.4	8.9	12.8	3.9	13.3	-2.8	21.6	5.0
11	32.2	20.6	31.1	21.7	32.8	19.2	26.7	11.7	28.9	14.4	25.0	13.9	16.7	0.6	16.1	2.2	21.1	11.1
12	32.8	21.1	31.7	23.3	29.4	16.7	26.1	11.1	29.4	16.7	26.7	15.6	18.9	1.1	20.0	5.6	20.5	4.4
13	32.2	21.7	33.9	22.2	29.4	18.3	28.3	11.1	29.4	17.2	27.8	14.4	21.7	0.6	23.9	8.3	22.2	7.7
14	33.9	21.1	32.8	22.2	31.1	17.8	29.4	11.1	26.7	18.3	26.1	16.7	17.8	3.3	17.2	13.3	13.8	2.7
15	31.1	22.2	30.6	23.3	28.9	17.8	30.6	11.7	9.4	-1.1	26.1	16.1	24.4	9.4	18.9	1.1	20.0	1.6
16	31.7	21.7	33.3	23.3	30.6	13.9	27.8	13.9	10.6	-4.4	28.3	18.3	16.7	11.7	20.6	6.1	21.6	7.2
17	32.8	21.1	32.8	22.8	31.7	20.0	20.0	13.9	19.2	-3.3	18.3	11.7	19.2	13.3	23.3	4.4	24.4	15.0
18	33.3	21.1	33.9	22.8	29.4	21.1	25.6	7.2	25.0	2.2	22.8	8.3	12.8	10.6	16.7	6.1	13.3	5.5
19	32.8	21.7	33.9	22.8	26.1	21.1	27.8	8.9	26.7	8.9	17.8	14.4	8.9	6.1	20.6	5.6	20.5	6.6
20	33.3	21.7	32.8	22.2	30.0	20.6	30.0	12.2	25.6	13.9	22.8	13.3	15.0	-2.2	18.3	7.8	22.7	10.0
21	33.3	22.2	31.7	21.7	30.0	20.0	30.6	16.7	25.6	15.6	17.2	12.2	20.6	4.4	19.2	6.1	28.8	16.1
22	33.9	21.7	30.6	20.6	31.1	18.9	28.3	16.1	26.1	16.7	21.7	13.9	23.9	10.0	17.2	1.7	20.5	15.0
23	35.6	22.2	32.2	18.3	32.2	18.3	27.8	18.3	27.2	17.2	19.2	16.1	24.4	11.1	15.6	3.9	24.4	13.8
24	36.1	21.1	33.3	21.7	32.8	19.2	27.2	14.4	27.2	15.6	23.9	16.1	23.9	15.0	13.9	6.1	26.1	16.1
25	36.1	23.9	33.3	21.7	27.2	21.1	27.2	12.8	26.1	16.7	25.0	16.7	23.9	13.3	21.1	12.2	26.1	14.4
26	35.6	23.9	33.3	22.2	21.7	19.2	28.9	11.7	27.8	17.8	25.6	12.8	23.9	10.0	17.8	7.8	18.8	13.8
27	28.3	21.7	33.3	21.7	19.2	11.7	30.0	17.2	24.4	16.1	21.1	17.2	23.9	12.2	18.9	11.7	21.1	12.7
28	33.3	20.6	30.6	21.7	21.7	12.8	29.4	16.7	16.7	1.7	21.7	15.6	15.6	7.2	11.1	1.7	21.1	8.3
29	32.8	21.1	28.9	22.2	23.3	16.7	30.0	17.2	17.8	6.1	20.0	11.1	16.7	1.7			17.7	7.2
30	32.8	21.1	33.3	22.2	27.2	12.2	30.6	18.9	17.8	7.8	18.3	4.4	20.0	1.1			20.0	5.0
31	31.1	21.7	33.3	21.7			29.4	17.2		—	20.0	4.4	21.7	5.0			25.0	7.2

TABLE 3.

MEAN MAXAMUM AND MEAN MINIMUM TEMPERATURES IN DEGREES CENTIGRADE, BY MONTHS FOR 1939, 1940 AND 1941 UP TO THE END OF MARCH, AT GAINESVILLE, FLORIDA.

DATE	TEMPERATURES		
1939	Mean	Mean Maximum	Mean Minimum
January	15.0	21.6	8.5
February	18.6	24.4	12.6
March	19.3	26.4	12.2
April	20.8	26.8	14.8
May	23.3	29.7	17.6
June	27.0	32.2	21.6
July	26.6	32.3	21.8
August	26.4	31.9	20.9
September	26.6	32.3	21.0
October	22.9	28.8	16.9
November	16.1	22.4	9.9
December	14.2	20.7	7.8
1940			
January	7.2	14.0	1.5
February	12.8	18.8	6.9
March	16.5	22.8	10.2
April	19.2	25.7	12.8
May	22.3	29.7	15.2
June	26.4	31.7	21.1
July	26.9	32.4	21.5
August	27.2	32.5	21.9
September	24.1	29.3	18.9
October	20.9	28.1	13.8
November	18.0	24.1	11.4
December	17.1	22.2	11.9
1941			
January	13.1	18.8	7.3
February	11.7	17.2	5.6
March	14.5	20.7	8.4

DATA FOR TEMPERATURE SERIES

July	18,	7:30 A.M.	air 29.5°C.	clear, sunny, calm.
July	30,	7:30 A.M.	air 27.3°C.	clear, sunny, calm.
August	4,	4:00 P.M.	air 29.5°C.	partly cloudy, rainy.
August	7,	10:00 A.M.		clear, sunny, calm. Temperature recorded by thermometer lying in the sun at 1:00 P.M. 52.2°C.
August	17,	8:00 A.M.	air 33.0°C.	clear, sunny, calm.
September	12,	1:00 P.M.		clear, sunny, calm.
September	22,	3:45 P.M.	air 35.1°C.	clear, sunny, calm.
September	29,	2:15 P.M.	air 26.7°C.	cloudy, cool, breeze. Following a five day period of cloudy, cool, rainy weather.
October	6,	3:00 P.M.	air 27.8°C.	clear, sunny, breeze. Waves on water. The previous week had been cool with nights at approximately 10.0° C. and approximately 27.0°C.
October	13,	3:00 P.M.	air 26.7°C.	clear, sunny, breeze. Waves on water. Nights of preceding days cool,—11.0°C. to 13.0°C.
October	19,	8:45 A.M.	air 17.8°C.	clear, sunny, calm. This series followed two nights of low temperatures and days of clear, calm weather with only moderately high temperatures.
October	25,	2:00 P.M.	air 27.2°C.	clear, sunny, high breeze. Waves on water.
November	3,	2:00 P.M.	air 26.7°C.	clear, sunny, cool breeze. Waves on water, high north wind.
November	9,	8:45 A.M.	air 13.1°C.	clear, sunny, cool. Waves on water, high wind. Following two nights of low temperature, 5.5°C. and 7.5°C.
November	16,	10:00 A.M.	air 6.1°C.	clear, sunny, calm, cool. Following two cold nights with temperatures at -1.0°C. and -4.5°C.
December	1,	9:45 A.M.	air 21.1°C.	cloudy, light breeze. The water level is about 1.5 meters lower than on July 18.
December	7,	1:45 P.M.	air 23.9°C.	clear, calm, warm.
December	22,	2:50 P.M.	air 23.9°C.	cloudy, windy. Waves on water.
January	14,	1:30 P.M.	air 19.2°C.	cloudy, calm. There have been heavy rains and the water level has risen above that of July 18 or any subsequent date.
January	21,	1:00 P.M.	air 23.9°C.	clear, sunny, warm. Light north wind making ripples on the water.
January	27,	4:00 P.M.	air 25.6°C.	clear, sunny, warm. Light wind making small ripples on the water.
January	31,	9:00 A.M.	air 12.2°C.	clear, sunny, calm.
February	12,	9:45 A.M.	air 10.6°C.	clear, sunny. Brisk north wind making waves on the water.
March	2,	10:00 A.M.	air 9.4°C.	clear, sunny, very light northwest wind. Following two cold days and nights with high wind.

water at the surface contains a relatively small amount of carbon dioxide; the amount increases rapidly with depth in the summer and early fall reaching a surprisingly high maximum towards the bottom of the thermocline. At this time of year there is also a high concentration of carbon dioxide in the hypolimnion but it decreases with depth. In the late fall and winter, when the cooling of the surface water causes it to mix with the water of the deeper strata, the thermocline is destroyed and the stagnation of the hypolimnion is overcome by the increasingly deep circulation of surface water. The high concentration of carbon dioxide in the water of the hypolimnion is greatly reduced when this circulation carries the deep water to the surface, allowing the carbon dioxide to escape into the air. These relations are summarized in Table 4, and illustrated in Figure 2.

The decrease in dissolved carbon dioxide and the increase in dissolved oxygen accompanying the mixing of the homothermous water of a lake is sometimes spoken of as "breathing of the lake."

Additional Physico-chemical Data:

Hydrogen Ion Concentration: The hydrogen ion concentrations were determined colorimetrically for water samples from different depths on July 30, August 7, September 22, and December 7. The water is slightly acid, the pH at all times, with one exception, lying within the limits of 5.3 to 5.9. These results are given in Table 5 and are shown in Figure 3.

On September 22 the pH fell outside the limits of 5.3 to 5.9, reaching the record low of 4.6. This is associated with the high value for carbon dioxide noted on this date. The low pH and high concentration of carbon dioxide coincide and occur in the thermocline just at that depth at which the dissolved oxygen becomes negligible or disappears. It is also worthy of note that in general the pH varies

TABLE 5

Giving the pH Values for Water at Different Depths on Different Dates for Lake Mize, 1940.

	Dates			
Depth	July 30	August 7	September 22	December 7
Surface	5.5			5.7
1 M.		5.9	5.6	5.7
2 M.		5.6		
3 M.			5.4	
4 M.		5.6	4.6	
5 M.		5.6		5.6
6 M.			5.3	
10 M.		5.8	5.4	5.5
15 M.		5.7		5.4
23 M.				5.4

TABLE 4

GIVING AMOUNT OF DISSOLVED CARBON DIOXIDE, OXYGEN AND PERCENTAGE SATURATION WITH OXYGEN AT DIFFERENT DEPTHS AND TEMPERATURES ON DIFFERENT DATES, IN LAKE MIZE, 1940, 1041.

DEPTHS	AUGCST 7				SEPTEMBER 22				OCTOBER 25				DECEMBER 7				JANUARY 27			
Surface	Temp. °C	CO_2 ppm.	O_2 ppm.	O_2 %Sat.	Temp. °C	CO_2 ppm.	O_2 ppm.	O_2 %Sat.	Temp. °C	CO_2 ppm.	O_2 ppm.	O_2 %Sat.	Temp. °C	CO_2 ppm.	O_2 ppm.	O_2 %Sat.	Temp. °C	CO_2 ppm.	O_2 ppm.	O_2 %Sat.
1 M.	19.5	25.5	0.0	00	31.5	4.8			25.0	4.5	5.6	67	18.3	6.0			20.3	6.2	5.7	62
2 M.	31.5				28.0	5.3	5.3	67	23.5				15.8	6.5	5.7	59	16.4			
3 M.	30.0	6.0	4.0	52	27.0	6.2			22.0	6.5	5.8	66	15.6	6.5			13.9			
4 M.	29.0	8.2	3.3	42	26.5	8.5	4.3	53	21.0				15.3	6.8			13.3			
5 M.	24.0				24.0	21.2	0.0	00	21.0	6.8	4.9	55	15.3				13.1			
6 M.	17.0	21.5	0.0	00	19.0	31.5			20.0	8.0	2.2	24	15.3	8.0	4.3	44	13.1	8.5	5.4	51
7 M.	15.0				16.0	31.0	0.0	00	18.0	22.0	0.4	4	”				12.8			
8 M.					15.0	29.8			16.0	26.6	0.0	0	”				”			
10 M.	13.0				14.0	27.5			14.5				”				”			
12 M.	12.0	17.9	0.0	00	13.0	26.8	0.0	00	13.5	23.5			15.3	9.0	4.4	44	12.8	8.5	5.3	50
13 M.						25.2							15.0	9.8			”			
14 M.														10.4			”			
15 M.														15.0			”			
20 M.	11.0	18.2	0.0	00	12.5	23.1			13.0	22.2			14.2	24.0	0.4	4	12.8	9.1	3.9	37
23 M.													13.6	24.5	0.2	2	12.8	9.7	3.5	33
														26.2						

with the amount of carbon dioxide in the water. As the amount of carbon dioxide increases the value of the pH decreases.

Transparency: The measurements for transparency were made by lowering a Secchi disc into the lake on two dates. The readings for these observations were,—August 7, 2.3 meters, and October 25, 2.5 meters.

General Water Analysis: The analysis of a sample of water from a depth of two meters, taken on August 7, gave the following results,—

Albuminoid NH_3	0.144 p.p.m.	Expressed as Nitrogen.
	The alkalinity in this water is due entirely to the presence of bicarbonates in solution, there are no carbonates present.	
Chloride	8.0 p.p.m.	
Free NH_3		No trace
Alkalinity	7.7 p.p.m.	Expressed as $CaCO_3$.
Nitrites	0.001 p.p.m.	Just a trace present.
Nitrates	0.000	No detectable amount.
Total dissolved solids	55.0 p.p.m.	

The water in the epilimnion is soft, unpolluted, and contains small amounts of organic and inorganic materials in solution.

Biology:

The distinction between animals and plants which are purely aquatic and those which are semi-aquatic is so ill-defined that both groups have been considered here. There is a profuse flora and fauna in the epilimnion associated with the high temperature and presence of dissolved oxygen.

Botanical Relations: The flora from the banks of the lake shows a zonation of plants ranging from those which are semi-aquatic in nature to those which are normally submerged. This zonation has been observed in the following categorical classification of the plants. The lake contains two semi-floating islands, a small one near the shore at one side of the main part of the lake and a larger one in the projecting bay. These islands are composed wholly of the plants indicated below as being found there.

PLANTS BORDERING LAKE MIZE

Trees		
Red-maple	*Acer rubrum* L.	
Water-tupelo	*Nyssa Biflora* Walt.	
Shrubs		
Gallberry	*Ilex Glabra* (L.) A. Gray	Common
Wax-myrtle	*Cerothamnus ceriferus* (L.) Small	Common
Saw-palmetto	*Serenoa repens* (Bartr.) Small	Common
Fetter-bush	*Desmothamnus lucidus* (Lam.) Small	Few
Herbs		
Bunch-grass	*Andropogon capillipes* Nash	Common
Beak-rushes	*Rynchospora* spp.	Few

Bugle-weed	*Lycopus pubens* Britton	Few
Dog-fennel	*Eupatorium capillifolium* (Lam.) Small	Few
Marsh-fleabane	*Pluchea foetida* (L.) DC.	Fairly common
— — —	*Ludwigiantha arcuata* (Walt.) Small	Common
Sundew	*Drosera capillaris* Plain	Scarce
Bog-bottom	*Lachnocaulon minus* (Chapm.) Small	Scarce
Yellow-eyed grass	*Xyris communis* Kunth	Fairly common

EMERGENT PLANTS

Shrubs		
Buttonbush	*Cephalanthus occidentalis* L.	Few
Sand-weed	*Hypericum fasciculatum* Lam.	Common
Herbs		
— — —	*Sacciolepis striata* (L.) Nash	Common
Cut-grass	*Leersia hexandra* Swartz	Common
St. John's wort	*Triadenum virginicum* (L.) Raf.	Common
Smartweed	*Persicaria hirsuta* (Walf.) Small	Common
Umbrella-grass	*Fuirena scirpoidea* Michx.	Common
— — —	*Ludwigia* sp.	Fairly common
Marsh-pennywort	*Hydrocotyle* sp.	Fairly common
Mermaid-weed	*Proserpinaca pectinata* Lam.	Few
Pipewort	*Eriocaulon compressum* Lam.	Common

SUBMERGED OR FLOATING PLANTS

Bog-moss	*Mayaca fluviatilis* Michx.	Abundant
Rush	*Juncus repens* Michx.	Scarce
Pond-grass	*Hydrochloa caroliniensis* Beauv.	Scarce
Spike-rush	*Eleocharis prolifera* Torr.	Common
Water-hyacinth	*Piaropus crassipes* (Mart.) Britton	Few

SEMI-FLOATING ISLAND PLANTS

— — —	*Sacciolepis striata* (L.) Nash
Cut-grass	*Leersia hexandra* Swartz
St. John's wort	*Triadenum virginicum* (L.) Raf.
Water-hyacinth	*Piaropus crassipes* (Mart.) Britton

Lake Mize has a variable water level, the variation probably exceeding a meter from season to season and year to year. The result of this is that at certain times, plants which are considered to be normally emergent or submerged are found growing successfully on the moist shore completely emerged, or in the case of the submerged plants they may be emergent at times. On the other hand some of those which normally grow out of the water will for a time grow successfully as emergents.

The study and identification of the plants has been carried out by Mr. A. M. Laessle, of the Department of Biology, University of Florida.

Zoological Relations: The fauna of Lake Mize has not been investigated thoroughly. The list of cold-blooded vertebrates, which is the result of studies carried out by Dr. A. F. Carr, the two species

of mayflies listed by Mr. Lewis Berner, and the two decapods reported by Dr. Horton Hobbs probably include all of the species of these three groups which occur here. The list of aquatic beetles as reported by Mr. Frank Young is probably almost complete, but may be added to as the study extends over a longer period of time. The determinations of the zooplankton, which has been examined by Dr. Hobbs, Mr. Dickinson and the junior author, are not complete and will be extended as the result of continued investigation.

COLD-BLOODED VERTEBRATES

Fishes	
Eastern Lake Chub-sucker	*Erimyzon sucetta sucetta* (Lacépède)
Florida Golden Shiner	*Notemigonus chrysoleucas bosci* Valenciennes
Marbled Brown Bullhead	*Ameiurus nebulosus marmoratus* (Holbrook)
Yellow Bullhead	*Ameiurus natalis* (LeSueur)
Tadpole Madtom	*Schilbeodes gyrinus* (Mitchill)
Red-finned Killifish	*Chriopeops goodei* (Jordan)
Ocellated Killifish	*Leptolucania ommata* (Jordan)
Golden Topminnow	*Fundulus chrysotus* (Günther)
Eastern Star-headed Topminnow	*Fundulus notti lineolatus* (Agassiz)
Least Killifish	*Heterandria formosa* (Agassiz)
Eastern Mosquito-fish	*Gambusia affinis holbrookii* (Girard)
Pirate Perch	*Aphredoderus sayanus* (Gilliams)
Florida Swamp Darter	*Hololepis barrattii* (Holbrook)
Blue-spotted Sunfish	*Enneacanthus gloriosus* (Holbrook)
Warmouth Bass	*Chaenobryttus gulosus* (Cuvier)
Bluegill	*Helioperca macrochira* (Rafinesque)
Florida Long-eared Sunfish	*Xenotis megalotis marginatus* (Holbrook)
Large-mouthed Bass	*Micropterus salmoides* (Lacépède)
Everglades Pigmy Sunfish	*Elassoma evergladei* Jordan
Salamanders	
Louisiana Newt	*Triturus louisianensis* Wolterstoff
Mud-eel	*Siren lacertina* Linnaeus
Frogs	
Cricket Frog	*Acris gryllus* (LeConte)
Common Bull-frog	*Rana catesbeiana* Shaw
Southern Bull-frog	*Rana grylio* Stejneger
Leopard Frog	*Rana sphenocephala* (Cope)
Snakes	
Florida Banded Water-snake	*Natrix sipedon pictiventris* (Cope)
Turtles	
Florida Snapping-turtle	*Chelydra serpentina osceola* (Stejneger)
Florida Cooter	*Pseudemys floridana peninsularis* Carr
Nelson's Terrapin	*Pseudemys nelsoni* Carr
Chicken-turtle	*Deirochelys reticularia* (Latreille)
Southeastern Soft-shelled Turtle	*Amyda ferox* (Schneider)

LARGER CRUSTACEANS (DECAPODS)

Cambarus fallax Hagen
Palaemonetes paludosa (Gibbes)

INSECTS

Predaceous Water Beetles, Family Dytiscidae

Canthydrus gibbulus (Aubé)	Rare, in vegetation around edge.
Laccophilus proximus Say	Common, in vegetation around edge.
Hydrovatus compressus Sharp	Rare, in vegetation around edge.
Desmopachria granum (LeConte)	Common, in mud around edge.
Bidessus exiguus (Aubé)	Common, in mud around edge.
Bidessus floridanus Fall	Rare, around edge.
Hydroporus hebes Fall	Scarce, around edge.
Copelatus chevrolati Aubé	Rare, in vegetation around edge.
Coptotomus interrogatus obscurus Sharp	Rare to common, around edge.
Thermonectes basilaris (Harris)	Rare, around edge.
Cybister fimbriolatus (Say)	Rare to common, around edge, and sometimes in deeper water.

Whirligig Beetles, Family Gyrinidae

Dineutes carolinus LeConte	Extremely common, on surface.
Gyrinus elevatus LeConte	Rare, on surface.

Creeping Water Beetles, Family Haliplidae

Peltodytes floridensis Matheson	Common, in vegetation.

Water Scavenger Beetles, Family Hydrophilidae

Tropisternus blatchleyi d'Orchy	Rare to common, in vegetation.
Tropisternus striolatus LeConte	Rare, in vegetation.
Tropisternus lateralis (Fabr.)	Rare, in vegetation.
Hydrocharis castus (Say)	Rare, in vegetation.
Helocharis maculicollis Mulsant	Rare, in vegetation.
Enochrus ochraceus Mulsant	Rare, in vegetation.
Paracymus nanus Fall	Common, in vegetation and debris.
Hydrochus inaequalis LeConte	Common, in vegetation and debris.
Hydraena marginicollis (Kies)	Rare, in vegetation and debris.

Mayflies

Callibaetis floridanus Banks	On vegetation.
Caenis diminuta Walker	On vegetation and sprawling on the bottom.

PLANKTON

The plankton was obtained by filling a Kemmerer water bottle at desired depths and straining the water through plankton silk of approximately one hundred meshes to the inch.

On August 7, 1940, twelve litres of water were taken from depths of two and ten meters and strained to obtain plankton samples.

On October 25, 1940, ten litres of water were taken from depths of three and ten meters and strained to obtain plankton samples.

On both occasions the crustacean plankton from the epilimnion was rich in quantity but from the hypolimnion it was poor. The predominating forms collected were:

Copepods	
Diaptomus floridanus March	Most abundant.
Cyclops leuckarti Claus	Fairly abundant.
Cladocera	
Daphnia longispina (Muller)	With helmet of moderate size and with eggs.
Bosmina lingispina Leydig	

The cladocerans were about equal in abundance to the *Cyclops*.

In addition to these Crustacea there were Copepod nauplii, rotifers and a considerable amount of phytoplankton, mostly green algae, none of which were identified.

The plankton samples also contained a few insect larvae, mostly *Corethra*. One small *Corethra* larva was taken in the epilimnion, and eighteen were taken in the hypolimnion. On August 7, a twelve liter sample from the hypolimnion contained seven *Corethra* larvae, and on October 25, a ten liter sample from the hypolimnion contained eleven *Corethra* larvae.

During the summer and fall the cold, non-oxygenated water of the hypolimnion contains a relatively large population of *Corethra* larvae but probably supports very little other life.

DISCUSSION

In spring or early summer the surface water of the lake warms rapidly, and as it warms it becomes lighter so that it does not mix with the cold heavier water below. This brings about a stratification of the water in the lake, so that the cold, deep water is isolated from the air and remains stagnant throughout the summer and early fall. As a result of this stagnation it remains cold, cannot replace its oxygen lost through respiration of aquatic animals and bacteriological metabolism, and accumulates large quantities of carbon dioxide which cannot be thrown off. This precludes the possibility of any forms of life existing in the hypolimnion during the summer excepting those which can persist in the almost total absence of free oxygen and in the presence of large quantities of carbon dioxide.

During late fall, with the onset of cold weather and in particular of the cold nights, there is a progressive cooling of the water in the lake. This cooling takes place from the surface. As the surface is cooled convection currents set up by the cool surface water, and by some associated wind action, carry and stir this cooled water into the water just below, which being warmer is cooled by contact, mixing and some conduction, or it rises to the surface to replace the cool water which has sunk and it is in turn cooled.

As the cooling thus proceeds, the effects are forced deeper, until finally the water in the whole lake becomes homothermous. From this time on, as winter progresses, the temperature of the lake water as a whole becomes colder, until the cooling is finally arrested by the onset of warmer spring weather. Examination of the groph, Figure 1 will show the upper stratum of water gradually cooling during the fall and the deep water of the lake gradually warming, until the lake becomes homothermous, after which the lake as a whole continues to become colder.

As fall and winter cooling progress the stagnation of the hypolimnion is destroyed, and there is progressively deeper stirring of the water until, when it becomes homothermous, it may be stirred all the way to the bottom. This stirring of the deep water and mixing it with the near surface water carries oxygen into the depths of the lake and allows the carbon dioxide to escape.

The result of this is to make the deeper strata of water temporarily inhabitable for animals which require a high concentration of free oxygen.

In spite of the small area of Lake Mize and the limitations imposed by the thin summer epilimnion of some four meters in depth, the fish population is particularly worthy of note. Not only is there a large number of fish present, but the nineteen species reported represent seventeen genera.

A phenomenon typical of conditions in Florida lakes, is the rapid warming of a thin layer of surface water as the result of a few warm days or even one extremely warm, sunny day. This is especially striking when it occurs during the winter, as it did on January 27, 1941, which was a clear warm day with an air temperature of 25.6°C., at four o'clock in the afternoon. In Lake Mize the temperature of the water at a depth of one meter was 16.4°C., and at the surface it had warmed to 20.3°C. There was an immediate biological response to this sudden rise in temperature displayed by *Rana sphenocephala,* when at four twenty in the afternoon these frogs burst into a wild chorus which persisted for about ten minutes.

The summer stratification has great significance in the ecology of lakes, limiting most of the aquatic organisms to that part of the lake which contains the requisite amounts of oxygen. When, as is often the case, an aquatic organism requires both cool water and a high oxygen content, the hypolimnion must be of such a size and nature that even during the most unfavorable year it will maintain an abundant supply of oxygen, otherwise the lake becomes uninhabitable for that species of organism.

This condition of thermal stratification, with its ssociated phenomenon of gaseous stratification, and fall and spring, or winter stirring, has the utmost significance in the economy of the lake and constitutes an integral part of the subject of limnology.

SOME CHEMICAL PROPERTIES OF THE PLANT NUTRIENTS AS RELATED TO THEIR UTILIZATION

O. C. Bryan
Soil Science Cooperative, Lakeland

Although the percentage of the mineral nutrients utilized by plants is relatively small, their functions are vital, constituting one of the fundamentals of the life process. The discovery of the essential nature of the secondary or trace elements in plant and animal life within recent years will go down in history as a major milestone in biological science. The trend is toward adding more to the list of mineral nutrients, and it is doubtful if sufficient information is available to enable one to separate the essential from the non-essential elements in the life process. Space will not permit a discussion of these developments here. The object of this paper is to explain in a general way the relation between the chemical properties of the known plant nutrients and their utilization by plants.

In general, the mineral elements absorbed by plants may be classified under two major divisions, namely, those which enter into the vital portions of the plant, such as nitrogen, phosphorus and sulphur and those which serve as catalysts, such as copper, manganese and zinc.

The cycle of minerals—from the soil to the plant and animal and back to the soil—is an ever interesting process which many accept without question as a law of nature. Yet, were it not for the fact that calcium phosphate is insoluble in water, this mineral could hardly be used for the bony skeleton of animals. This does not mean that bones consist of calcium phosphate. The simple chemical properties of these elements serve as a basis for bone formation.

The exact part played by the mineral nutrients in the plant is still more or less a puzzle, especially in regard to the proportion, kind and amounts utilized. Why some minerals are used in large amounts and others in small amounts may well become the object of much study. It is only natural to ask why potassium is utilized by plants to a greater extent than is calcium, when the soil generally contains much more available (replaceable) calcium than potassium. This might be explained on the basis that calcium compounds are more insoluble than similar compounds of potassium, and to the fact that potassium is a stronger base and somewhat radioactive. This however does not account for the specific function of each element in

the plant, as is clearly shown by the fact that sodium, though very similar to potassium in chemical properties, cannot substitute for it in the plant.

In a general way, the amounts of minerals absorbed from the soil or media are in proportion to the amounts surrounding the roots or absorbing units, providing due allowance is made for solubilities, affinities, and repelling forces. Assuming that the mineral content of plants was more or less fixed in proportion to the amounts available during the evolutionary or developing stages, then it would be logical to assume that the soil forming processes had undergone considerable changes from those of former ages. Pedological studies indicate that this is not necessarily the case. Furthermore, data show that the soil complex (clay, a product of decomposition of rocks) has a much stronger affinity for potassium than for sodium. This apparently accounts for the greater content of potassium in the soil than sodium, whereas just the opposite is true for ocean water. And this may offer an explanation for the differences in plant and animal requirements of these two nutrients.

It is interesting to note that nitrogen and phosphorus are both acid forming and that both occur in the same periodic group of chemical elements. Yet, the nitrogen utilized by plants is three to four times that of the phorphorus. One might ask if this were accidental, or just another of nature's laws. Since these nutrients are absorbed almost entirely from the soil, except in the case of legumes, as inorganic salts, these differences might be accounted for by the fact that nitrates are all soluble in water, are negatively held by the soil, and are easily shifted by the soil moisture, whereas the phosphates are all insoluble in water except sodium, potassium and ammonium, and are not easily moved or shifted by soil moisture. Moreover, it is a well established fact that active iron and aluminum in the soil will lower the solubility of phosphates to such a degree that plants are unable to secure the needed amounts of these salts. Other factors being equal, phosphates are absorbed by the plant in proportion to the concentration of the phosphate ion, which is greatly influenced by precipitating agents and reaction, as well as by the kind and amount of other elements or ions present. Taking all the data into consideration, the low phosphorus ultilization of plants compared to that of nitrogen is partially explained by differences in chemical properties of the nutrients making for solubility.

One might well ask the question why the ever abundant element silicon does not play a more vital rôle in the nutrition of plants than is apparent. This may be explained by lack of solubility of the silicates, all of which are either insoluble or too viscid ofr free move-

ment, whereas carbon, a closely related element forms less complex compounds that are generally more soluble. This, however, does not explain the specific functions of the two elements. But it is possible that the specific functions in the plant are the results of the specific properties of the elements themselves.

Two other similar elements, calcium and magnesium, occurring in the same periodic group, may be mentioned. Here calcium is utilized by plants in much larger amounts than magnesium, but the exact reason is not definitely known. However, data from many sources show that the soil complex contains several times as much calcium as magnesium, thereby making calcium constantly more accessible to the absorbing units. Moreover, magnesium forms more insoluble compounds with silicates which are so generally present, than does calcium. Thus the utilization of these two similar elements is in a measure dependent on their simple chemical properties making for solubility.

Similar questions may be asked regarding the utilization of iron and cobalt as well as other heavy metals. Assuming that the heavy metals exert catalytic influences in the plant (oxidation and reduction) one cannot ignore the fact that each is specific regarding the function or part played. Yet, why is iron required in greater amounts than cobalt and manganese? And, furthermore, why are only small amounts of iron utilized in the life process when there is such an abundance of this element in nature? These questions are partially answered by the fact that the soil contains relatively small amounts of replaceable or available iron, and still less amounts of cobalt and manganese. This is particularly true in view of the large amounts of iron in the soil system. These elements have a low solubility in water and during the weathering process of granite and other basic rocks, the alkaline condition produced further reduces their solubility.

This principle of the dependence of utilization upon those factors which make for solubility appears to prevail among most nutrients, and it would seem logical to assume that this principle has held during the development of the plant kingdom. It is probable that from the composite of minerals varying in degrees of solubilities and properties that plants utilized those which were most constant and ever present, partially in the order of simple solubility. Strange as it may appear, the chemical properties of an individual element persist whether inside or outside of the plant cell, unless removed from solution by the laws of solubility or biological processes.

In this connection it is of major interest to note that the known mineral nutrients are fairly well distributed throughout the periodic table of the elements. For example, group *I* with a combining rela-

tion of one, has potassium, sodium and copper, and in like manner group *II* has calcium, magnesium and zinc, group *III* boron, aluminum and possibly gallium, group *IV* carbon, silicon and possibly tin, group *V* nitrogen, phosphorus and possibly vanadium, group *VI* oxygen, sulphur and molybdenum, group *VII* chlorine, manganese, fluorine and iodine, and group *VIII* iron, cobalt and possibly others yet to be determined.

Just why the plant nutrients originated from such a variety of elements, and wide range of chemical properties is puzzling and not completely understood. But it appears that the elements function specifically, whatever that may be, and simultaneously to maintain the plant and possibly the "Spark" of life itself. Who knows but that this range of chemical properties of different elements, manifested by varied degrees of solubilities and consequent availabilities, electrical properties, etc., may not be the basic starting points of plant life, and that the utilization of the minerals from the soil is merely a filling of the gap, or the needs of this eternal cycle of plant and animal life?

THE TAXONOMIC STATUS OF **Pinus caribaea** MOR.

WILBUR B. DE VALL
University of Florida

The purpose of this paper is to present in detailed form such taxonomic characters of the species slash pine, *Pinus caribaea* Mor. as have been used in some of the tree manuals and to add new characters of identification that will help in separating taxonomically the previous species from its closely related species, swamp pine, *Pinus palustris* Mill.

The above specific names for slash and swamp pine respectively are used by Small.[1] Since this classification is new to most of us, a brief explanation should be made concerning the nomenclature used in other manuals. Most publications have in the immediate past recognized only longleaf pine, *Pinus palustris* Mill, and slash pine, *Pinus caribara* Mor., as being the major turpentine species in the southeastern United States. Small uses a similar classification with a somewhat different meaning.[2] His classification is as follows: longleaf pine, *Pinus australis* Michx. f., swamp pine, *Pinus palustris* Mill., and slash pine, *Pinus caribaea* Mor.

The discussion which follows uses this latter classification, showing in detail such taxonomic characters as will substantiate the classification as well as those that will not. Previous to this study no one had felt justified in upholding the characters in the manual because a thorough study had not been made of the swamp and slash pine. With this complex problem at hand and demanding solution if possible, the investigation materialized through the cooperation of the School of Forestry and the Herbarium of the Florida Experiment Station, both located at the University of Florida.

Areas Investigated

The study covered a distance of some twelve hundred miles into central Florida, the eastern Atlantic coast from Vero Beach southward to Big Pine Key and the Gulf coast from Naples northward to Aripeka, thence inland to Brooksville and return to Gainesville. This route was decided upon after much consideration as to where the borders of the species range might be encountered as well as where variations might occur due to soil type, nearness to salt water and topography of the land.

[1]J. K. Small, *Manual of the Southeastern Flora* (New York, Published by the Author, 1933) p. 4.

[2]*Ibid.*

Study Methods

The intentions in making the study were to collect suitable herbarium material over the range of the species that might be filed for future reference, and also to record variations in the species due to environmental influences. As the investigation proceeded, much more detailed observations became necessary. Briefly, the data were obtained in the following manner.

A sample of the foliage, including twig, needles and bud as well as the cones from the same tree were collected from each county and from several places within each county as was deemed advisable. Each sample was placed in a large paper bag and labeled in detail, giving the county, nearest town, date, species, and characteristics peculiar to the tree from which the sample was taken. In nearly all cases material was obtained from second-growth or mature trees rather than small trees and from branches well up on the crown of the tree.

In addition to the main collecting, other data were obtained on distribution, measurements on cones, fascicle sheaths and the number of needles per fascicle. Seedlings were collected from the vicinity in which the sampling was done when such were present so that the picture regarding the species should not be lacking in any respect.

Observational Approach to the Study

Investigations of a research nature are not to be conducted for the purpose of proving a theory. They are to be made with a theory or hypothesis in mind which is to be proven false in every way unless it is impossible to do so. In the event that the theory remains without a falacy at the end of the investigation, it may be considered dependable and superior in rank.

This was the attitude behind the study. As a hypothesis the classification of *P. caribaea* as mentioned previously was accepted and all characters used in it were tested and tried under various conditions of environment.

Before further consideration is given to the findings of the investigation, some of the key factors that were influential in guiding the study will be mentioned. First of all, the manual states that slash pine is "The only pine growing naturally on the Florida keys." This statement was responsible for continuing the study onto the Keys so that a "type" species might be observed.

Another important statement in the key refers to swamp pine as "Inhabiting the lower or wet situations with the range of *P. australis*. . . ." This was used as a key to distribution of the species and as an index as to where *P. caribaea* might be found. As will be brought out later, each species of pine considered in this paper is characterized by a particular type of habitat.

TAXONOMIC OBSERVATIONS

The data obtained in this study will be presented in the following order: cone characters, needle characters, seedling characters, growth habit and distribution, using the manual characters as the hypothesis.

Cones

Hypothesis: *Pinus caribaea* cones exhibit the following characteristics: "cones elongate of a conic type and over twice as long as thick when closed, slightly unbonate . . . .8-15 cm. long, recurving when young, cylindric-conic when closed, cylindric or ovoid-cylindric when open . . . . the scale appendages flat or slightly elevated, with recurved or hooked prickles . . . . cone scales thick-edged."

According to the hypothesis, cones must of necessity be elongate and somewhat cylindrical to meet the requirement of being twice as long as thick when closed. An open cone which is of the ovoid type cannot be cylindric when closed. As this character is used as superior in rank to any others, it was deemed advisable to check the consistency of it so that it would or would not be possible to say that it is a distinguishing character.

In order to differentiate between slash and swamp pine when only open cones are available, one must soak a cone to a closed condition to be sure that the dimensions of the long axis are more than twice those of the short axis to class it as *P. caribaea.* This is a tedious process and it would seem that such a character is not worthy of ranking first in any key unless it is the most accurate and dependable. Certain cones that are definitely cylindrical when open will be cylindrical when closed.

From a thorough study on the relative shrinkage of cones from an open to a closed condition it was found that certain sized cones within a given range of widths would close up to be well within the limits stated for slash pine. Others that appeared to have a possibility of closing up to give the length equal to more than twice the width, did not prove to do so. The cone dimensions given in Table 1 show the ranges within which slash pine cones will and will not substantiate the characters in the key. These data were obtained from a series of measurements on forty cones and summarize the data on open measurements and the corresponding closed measurements on the same cone. As the length of a cone is altered very little in closing, all data were grouped by one-centimeter length classes and analyzed, giving the data occuring in the table.

The tabulation represents data taken over several counties in south Florida including Big Pine Key and shows that the length of a cone being twice its width when closed, cannot be generally used as a

taxonomic character for slash pine because many cones collected well within the species range were less than twice as long as wide when closed.

The hypothesis states that cones for the species range from 8-15 cm. in length. Again a check was made on this character to see which samples would be eliminated.

Careful check measurements were made on an average cone from each sample and the following exceptions noted, that is, having cones not within the limits of the species. Cones from Pasco, Pinellas, Hillsborough, Sarasota, Lee, Monroe (Big Pine Key), Dade, Broward, and Palm Beach counties were found less than 8.0 cm. in length. From the above observations and by using the characters in the key, these cones could not have come from slash pine, yet were collected only within the range of the species. Furthermore, eight centimeters was found to be the obvious dividing line between the cylindrical type of cone and the ovoid type, when closed. However, this minimum length limit is not to be accepted because several cones that measured 7.0 cm. in length did not have proportional width to make them less than twice as long as wide. It was noted that cone length and width might be sufficient to cause the length to be twice the width but did not place the cone within the specified limits of 8-15 cm. One cone measured only 6.5 cm. in length, yet was twice as long as wide when

TABLE 1.—CONVERSION TABLE FOR REDUCING OPEN-CONE DIMENSIONS TO CLOSED-CONE DIMENSIONS FOR *P. Caribaea*

1. Cones that measure 5.0-5.5 cm. in length when open and not less than 4.5 cm. in width, will be less than twice as long as broad when closed.
2. A cone measuring 5.6-6.5 cm. in length and not more than 5.0 cm. in width will be twice as long as wide when closed; above 5.0 cm. in width it will be less.
3. Cones measuring 6.6-6.9 cm. in length and not more than 4.7 cm. in width will be twice as long as broad when closed.
4. Cones 7.0 cm. long and 6.0 cm. or more in width will be less than twice as long as broad when closed.
5. Cones ranging from 7.2-7.9 cm. in length and not exceeding 5.7 cm. in width will be twice as long as broad when closed.
6. Cones 8.0 cm. long and more than 5.0 cm. in width will be less than twice as long as broad when closed.
7. Cones measuring 8.5 cm. in length and not exceeding 6.7 cm. in width, will be more than twice as long as broad when closed.
8. Cones measuring 9.0-9.9 cm. in length and not exceeding 7.5 cm. in width will be twice as long as broad when closed.
9. Cones measuring 10.0-10.9 cm. in length and not exceeding 7.7 cm. in width will be more than twice as long as broad when closed.
10. Cones measuring 11.0-11.9 cm. in length and not exceeding 7.7 cm. in width will be twice as long as broad when closed.
11. All cones over 12.0 cm. in length regardless of width will be twice the width when closed.

closed. Another cone measuring 8.0 cm. in length was less than twice as long as wide when closed.

The hypothesis states that slash pine cones have recurved or hooked prickles on the scale appendages. This character was studied while collections were being made in the field and again when the materials were being analyzed in the office to see if such could be relied upon as a stable character.

The data obtained from forty cones, examined expressly to determine the curvature of the prickles, showed it to be unreliable. A summary of this analysis is given in Table 2.

TABLE 2.—SUMMARY OF DATA ON PRICKLE CURVATURE ON CONES OF *P. caribaea*.

County	Recurved	Straight	Decurved
Hernando		X	X
Pasco	X	X	X
Pinellas	X	X	X
Hillsborough		X	X
Manatee		X	X
Sarasota		X	X
Lee		X	X
Monroe (Big Pine Key)			X
Dade	X	X	X
Broward	X	X	X
Palm Beach		X	
Martin	X		
St. Lucie		X	X

Mention should be made at this time of an observation in Collier county just north of Naples. Two trees were growing side by side and one had cones on which the prickles were decidedly decurved whereas the other had distinctly recurved prickles. As a taxonomic character, this is variable and cannot be used freely in a diagnosis of the species.

Cone scales, according to the manual, are thick-edged as compared with the thin-edged scales of longleaf pine. Several instances were noted in the field where the edge of the scale, due to its exposed portion being compressed laterally, had the appearance of being thin. Even though the scale was thin the edge was rounded instead of being acute which may be the interpretation meant in the key. This character, however, has not been found adequate to separate slash from swamp pine.

Although no mention is made of color in the hypothesis, slash pine has a brown cone when fresh which is shiny, giving it a varnished appearance. Had this character been included in the key, much uncertainty could have been prevented. Swamp pine cones have a brown, shiny appearance very similar to those of slash.

The cones of slash pine are stalked. The stalk was found to vary in length reaching a maximum of one-half inch. Some of the manuals refer to this species as having short-stalked cones but a stalk of the above length could hardly be called short.[3] The stalks were found to be both persistent on the twig with a few basal cone scales when the cone falls as well as deciduous with the cone. No apparent difference was found in the length or nature of the stalk in the slash and swamp pine.

Needles

Hypothesis: *Pinus caribaea* needles show the following characteristics, " . . . . leaves in 2's and 3's, 18-30 cm. long (rarely shorter), bright green on twigs about 5 mm. in diameter. . . ."

Observations throughout the study revealed that needle length is variable and only in a comparative way can it be used taxonomically. The specimens collected on Big Pine Key indicate that the common number of needles to be found in a fascicle is two. The number of needles per fascicle for swamp pine is inconsistent, both two and three-needle fascicles, with a slight tendency toward three per fascicle. Color of needles is again a comparative character and is considered here as being of little taxonomic significance. Samples taken two miles west of West Palm Beach revealed needles of two different colors on two adjacent trees. These were undoubtedly of the same species, slash pine. One tree had needles blue-green in color whereas the other had needles that were dark-green.

A taxonomic character, though not included in the hypothesis should be mentioned here for comparison. The length of the fascicle sheath is often of diagnostic value in separating species of hard pine.[4] As this character was studied in the present investigation for slash pine and in a previous investigation for longleaf and swamp pine, a summary of the data will be given here. The range of sheath measurements for the three species of southern pines is as follows:

1) *P. australis*, .60"-1.50", 2) *P. palustris*, .30"-.50" and 3) *P. caribaea*, .40"-.55".

Another diagnostic character, the number of resin ducts in the cross-section of the needle has been given special attention by Harlow.[5] As resin ducts are a part of the needle anatomy they should be re-

[3]William M. Harlow and Ellwood S. Harrar, *Textbook of Dendrology* (New York and London: McGraw-Hill Co., 1937), p. 92.

[4]W. B. De Vall, "A Diagnostic Taxonomic Constant for Separating Slash and Longleaf Pines," *Proceedings of the Florida Academy of Sciences*, Vol. 4, 1939, p. 113.

[5]W. M. Harlow, *The Identification of the Pines of the United States, by Needle Structure* (Syracuse, N. Y.: 1931).

liable and consistent. He shows slash pine by means of a photomicrograph as having two resin ducts, occasionally with a third duct medial in position.

At the termination of the field work, microtome sections were made on all needle samples and the results are shown in Table 3. This gives the number or frequency of resin ducts according to the county in which collected. All sections were made at one-half the length of the needle so that the resin duct count would not be in error due to selection of the place of sectioning. In all cases sections were made from two-needle fascicles.

TABLE 3.—FREQUENCY OF RESIN DUCTS IN *Pinus caribaea* NEEDLES.

Sample No.	County	No. ducts per cross-section	Notes
69	Monroe	5	Big Pine Key
50	Dade	5	S. Coral Gables
12	Dade	4	S. Coral Gables
66	Broward	6	3 mi. W. Deerfield
48	Broward	8	3 mi. W. Deerfield
56	Broward	6	W. of Pompano
28	Pinellas	6	N. Tarpon Springs
33	Lee	8	S. Fort Myers
64	Broward	4	W. of Deerfield
63	Broward	8	W. of Dixie
65	Palm Beach	8	2 mi. W. Palm Beach
52	Palm Beach	7	2 mi. W. Palm Beach
60	Palm Beach	7	3 mi. S. Delray
61	Palm Beach	5	Lake Worth
53	Martin	7	Stuart
51	St. Lucie	9	W. Fort Pierce
23	Collier	6	N. of Naples
15	Collier	7	N. of Naples
8	Lee	6	N. of Estero
20	Hernando	8	Aripeka Road 15
32	Pasco	9	Hudson-Aripeka
17	Pasco	7	New Port Richey
24	Pasco	6	Hudson-Aripeka
6	Pasco	5	Hudson-Aripeka
39	Pasco	8	N. of Aripeka
22	Pinellas	8	N. edge Clearwater
16	Pinellas	8	N. of Dunedin
18	Hillsborough	6	W. of Tampa, Rd. 17
21	Hillsborough	5	S. edge of county
10	Manatee	6	N. of Parish
36	Manatee	6	N. of Parish
25	Sarasota	9	North of city
9	Sarasota	5	S. edge of county
1	Sarasota	6	S. edge of county
2	Sarasota	6	S. of Venice
37	Charlotte	6	N. of Punta Gorda
3	Lee	9	N. of Bonita Springs
19	Lee	7	N. of Bonita Springs
14	Pinellas	3	N. of Tarpon Springs
58	St. Lucie	3	Inside the bay

In the table it is interesting to note that in all but two cases the number of resin ducts per needle ranged from four to nine. One of the exceptions was found on road No. 19 north of Tarpon Springs, Pinellas county, and the other at Vero Beach just inside the bay, St. Lucie county. As was observed at the time of collection, both of these locations are in the northern part of the range of slash pine where it becomes limited to only a narrow belt adjacent to the coast. There is a possibility that the species sampled and recorded as slash pine may have been swamp pine because of the nearness to the transition of the ranges of the two species.

Seedlings

Information is not given in the key as to the type of seedling produced by slash pine. Based upon common knowledge and what has long been known to exist regarding types of seedlings, the following brief review is included.

The longleaf pine is known to have a seedling which passes through a grass stage. The needles are long, three per fascicle and the main stem is large in diameter and remains unbranched until it passes the grass stage which is often at a height of from two to five feet. It has a terminal bud with white bud scales situated in the center of the needle cluster.

The typical seedling of swamp pine is found around flatwoods ponds and on other low ground within the range of longleaf pine. It is spindly in appearance and does not pass through a grass stage. It has medium-lengthed needles, occuring two and three per fascicle. The stem of the seedling is rarely larger than a pencil until about the second or third year of growth when it enlarges and immediately produces lateral branches.

The typical slash pine seedling found in southern Florida and observed as far north on the east coast as Fort Pierce, south to Big Pine Key and as far north on the west Florida coast as Aripeka in Hernando county, could be described as having the general appearance of both of the above mentioned species. The needles are of medium length and occur two and three per fascicle. This seedling like the longleaf seedling passes through a definite grass stage. The stem on a seedling measuring eight inches in height has a diameter of 1⅛″ at the ground level. Seedlings which are coming out of the grass stage have lateral branches developed at not more than one foot above the ground.

It is interesting to note in this connection that the Florida State Forest Nursery planted in their seed beds, two lots of pine seed, one collected in the vicinity of Lake City, Florida, and the other collected

in the southern part of the state below Sebring, Florida. As a result of this planting the following quotation from Mr. T. W. Young is included.[6]

> "During the past spring, (1934) Mr. D. J. Weddell, of the Florida Forest Service noted that the seedlings in certain beds at the State Nursery were markedly different from those about them; even though they were on identical soil and had received the same care, records showed the seed used in these particular beds were collected in the vicinity of Highlands Hammock by boys of the C.C.C. camp at Sebring.
>
> "Measurements taken on August 28, 1934, by the present nurseryman, Mr. T. W. Young, show that the average height of the trees grown from south Florida seed is about three and one-third inches as compared with more than seven and one-half inches for those grown from seed collected in north Florida. In addition, the seedlings grown from seed collected in the southern part of the state had developed a stem of only about three inches, terminating in a cluster of needles very similar to those of the longleaf pine seedling. The north Florida seedlings have needles from near the ground to the tip of the stem, growing in a well distributed manner without bunching."

The seedlings referred to above were distributed by the nursery to various parts of the state to test them out. One shipment went to Mr. D. Howell, of Lake City, Florida, who planted them on his own land; one plantation of northern seedlings and one of southern stock. A recent interview with him revealed that nearly 100% mortality was experienced with the stock grown from southern seed, whereas the seedlings grown from northern seed have grown nicely with only about a 20% mortality.[7]

Whether or not a definite, visible, taxonomic character can be found that will supplement those in the key, the fact remains that some inherent character is present in slash pine to produce a seedling of the type described above.

Growth Habit

In addition to the previous description of slash pine seedlings, much is to be said concerning the growth habit of the species in stages advanced from that of the seedling. The seedlings, of a type intermediate between longleaf and swamp pine, were found in various habitats. In an old field grown up to wire grass (*Aristida sp.*) which had not been burned for at least five years, seedlings of slash pine were found in the grass stage. On Big Pine Key, slash seedlings were found on limestone rock with only accumulated soil on the surface for their roots to penetrate. Very little ground vegetation is present under such conditions.

[6]Letter from Mr. T. W. Young, Nurseryman with the Florida Forest Service, 1934.

[7]Statement of Mr. D. Howell, personal interview.

Various observations were made throughout the entire study to note any characteristics of the crown peculiar to the species. Slash trees observed along the east and west Florida coasts had much smaller crowns in proportion to their diameter than their north Florida relative, the swamp pine.

Increment cores were not taken to determine age or growth but Dr. Gifford, of the University of Miami, reports that trees in that vicinity have been proven to put on forty-five growth rings in a period of fifteen years.[8] This would mean the addition of three rings of growth a year instead of the normal one. The reason for this has not been determined unless it is the effect of a continuous growing season combined with frequent and alternate wet and dry periods.

A typical stand of mature slash pine on Big Pine Key exhibited a characteristic sweep in the trunk due to frequent high winds of hurricane velocity.

The type of bark found on slash trees on Big Pine Key is different than that commonly found on swamp pine in northern Florida. Slash pine has thinner bark plates, orange-purple in color, than swamp pine which has a gray bark until over twelve inches in diameter when it starts to become orange. The bark plates also show a tendency to scale off on trees approaching twelve-inches in diameter. This characteristic is not evident in swamp pine for corresponding diameters. This difference may be in part influenced by environment but should be included here as a characteristic of the species. The type of bark found on swamp pine for the same diameter of tree, has a long, rough, gray bark plate which remains in this condition until the tree reaches a larger diameter than that referred to for the slash pine above.

Distribution

Hypothesis: *Pinus caribaea* is found on "dry sandy or rocky soils, often calcareous, peninsula of Florida and the lower Keys, extending near the coast to Mississippi and Georgia. The only pine growing naturally on the Florida Keys."

Using the above notes on distribution of slash pine, the investigation into its distribution was one of determining the exactness of this range. The key note regarding distribution is that the species is the only pine found naturally on the Florida Keys. The species was found along the Florida east coast in a narrow belt as far north as Fort Pierce. This is not the northern limit of the species but is the most northern point on the coast where it was observed. In all of the collecting done along this portion of the coast, a short trip of from two to five miles was made inland from the coastal U. S. Highway No.

[8]Statement of Dr. J. C. Gifford, personal interview.

1 at various points, to obtain samples from trees in their inland habitat and so that some note could be made on the extent of its distribution inland from the coast. A very interesting point brought out in this connection is that slash pine is not found on the sand-bar island off the mainland from Vero Beach to Miami.

In the Homestead region of Dade county, slash pine was observed to extend southward nearly to the edge of the mainland. There are no pines growing on the upper Florida Keys between the mainland and Big Pine Key. The long Over-Seas Bridge reaching its terminus on Big Pine Key brings one into an entirely different vegetation and soil type than that found on the upper Keys. It is on this Key that a fine stand of slash pine was observed and the major part of the detailed taxonomic work completed. This Key was used to furnish typical material for checking all characteristics in the hypothesis and it is with reference to these samples, supplemented by other samples within the range of the species, that the previous discussion was made. Slash pine inhabits the major portion of Big Pine Key. The distribution of the species south and west of this point on the Keys was not included in the study. Slash pine was found to inhabit only the islands in the Everglades region and no collecting was done or observations made in this portion of the state.

In extending the study up the Gulf coast north from Naples, some very interesting observations were made on distribution of slash pine. It was found to be the only species of pine inhabiting the flatwoods type of land. Also in this region, slash pine is not used for naval stores because it does not produce the flow of gum that is characteristic of the more northern swamp and longleaf pines.

A short distance north of Bradenton on Highway No. 41 longleaf pine was encountered at the south boundary of Hillsborough county, extending into Manatee county only in the extreme northern part. It was at this location that the first trees of *P. palustris* were observed. They were growing on the edge of a hammock with the slender type of seedling scattered in the vicinity. Theoretically, this should demarcate the transition zone separating slash pine from the other two associated species namely, swamp and longleaf pines.

Progressing westward on Route No. 17 between Tampa and Clearwater an abrupt change in topography was noted and observation revealed the typical slash seedlings of the type found on Big Pine Key. A little farther west in the vicinity of Clearwater, slash and longleaf pine were found very close to salt water. The slash trees were only few in number and limited to the immediate shoreline. The typical seedling of slash pine was again found north of Tarpon Springs in Pinellas county and also in two localities where samples were taken

near Aripeka in Hernando county. In each case the needles were two and three per fascicle and possessed buds with brown scales. As this was the most northern point studied near the coast, the records are incomplete north of road No. 15 from Aripeka to Brooksville. Only a few miles inland towards Brooksville, longleaf pine inhabits the rolling land along with various species of scrub oak.

Thus it can be seen, that the range of *P. caribaea* becomes limited in its more northern distribution to a very narrow strip or belt near the coast. This belt did not appear to be continuous but rather to form small strips and islands of pine separated by either open or marsh-grass areas. On the western side of the peninsula the range swings inland just north of Parish and is again represented on the east coast in the vicinity of Fort Pierce. Data is lacking on the inland distribution of the species and on the distribution northward on both the east and west Florida coasts.

The distribution of the species was thought, perhaps, to be correlated with soil type. However, this was not found to be the case as the major soil types of the state are not continuous with the range of the species. It is evident that the species range is in the form of a widely-spread Y coinciding in part with the calcareous soils found along each coast.

TESTS AND STANDARDS FOR SHARK LIVER OIL FROM SHARKS CAUGHT IN FLORIDA WATERS

L. L. Rusoff
University of Florida
and
Robert M. French
Shark Industries, Inc., Hollywood

Shark liver oil, known commercially as "Elbrol" and "Shark Liver Oil—Shark Industries" is a Florida product. The oil is obtained from livers of sharks found in the tropical waters off the coast of Florida, mainly of the variety *Hypoprion brevirostrus* (lemon), but any or all of the following varieties may be included: *Odontaspis littocalis* (sand), *Isurus punctatus* (mackerel), *Triakis semifasciatum* (leopard), *Sphyrna zygaena* (hammerhead), *Carcharias milberti* (white) and *Carcharias limbatus* (black tip). It is extracted from the liver with live steam, washed with dilute sodium hydroxide and filtered. The oil is valued particularly for its high vitamin A content. "Elbrol" is used extensively in poultry nutrition. Tests with growing birds at the Florida Agricultural Experiment Station have shown "Elbrol" to be three times as potent as U.S.P. XI reference cod liver oil which contains 3,000 units of vitamin A per gram.[1] It is also being used in the nutrition of dogs, mink and other animals. Recently, shark liver oil in capsule form has been placed on the market for human consumption. It is biologically assayed to have a potency of not less than 16,500 U.S.P. XI units of vitamin A per gram and of not less than 40 units of vitamin D (U.S.P. XI) per gram. "Shark Liver Oil-Shark Industries" has been approved recently by the Council on chemistry and Pharmacy of the American Medical Association.[2]

Some tests and standards are available for shark live oils from sharks caught in other parts of the world, particularly Japan,[3,4,5,6] but

[1]L. L. Rusoff and N. R. Mehrhof, "Shark Liver Oil—A Potent Source of Vitamin A for Poultry," *Poultry Science,* Vol. 18 (1939), pp. 339-344.

[2]"Report of Council on Chemistry and Pharmacy," *Jour. Amer. Med. Assoc.,* Vol. 115 (1940), p. 683.

[3]J. Lewkowitsch, *Chemical Technology and Analysis of Oils, Fats and Waxes.* (Vol. II, London: Macmillan & Co. Ltd., 1914).

[4]M. Tsujimoto, "Squalene: A Highly Unsaturated Hydrocarbon in Shark Liver Oil." *Jour. Ind. Eng. Chem.,* Vol. 12 (1920), pp. 63-72.

[5]M. Tsujimoto, "Man-Eating Shark Liver Oil." *Jour. Soc. Chem. Ind., Japan,* Vol. 39 (1936), pp. 82-83. (suppl. binding) (from *Chem. Abstracts,* Vol. 30, p. 5438).

[6]M. Tsujimoto, "Marine Animal Oils," *Jour. Soc. Chem. Ind., Japan,* Vol. 40 (1937), pp. 184-186. (suppl. binding) (from *Chem. Abstracts,* Vol. 31, p. 6492).

none have been reported for liver oils from sharks caught in Florida waters. Since the shark liver oil industry has been making rapid strides in the last few years, it seemed desirable to have some tests and standards for the identification of Florida shark liver oil. Also, these tests and standards will become more significant since World War II has presented difficulties in procuring cod liver oil from foreign markets. It is probable that there will be a shortage of cod liver oil in the United States this winter. Prior to the war about 70 percent of the imported cod liver oil came from the Scandinavian area and the remainder from Japan and Iceland. Thus, the Florida shark liver oil industry is due to prosper this winter.

The following tests and standards are reported for Florida shark liver oils as determined by the methods in the United States Pharmacopeia XI.[7]

Shark liver oil is an amber to brown oily liquid, possessing a fishy odor and taste. It is insoluble in water, slightly soluble in alcohol, and soluble in chloroform, ether, benzene, ethyl acetate and carbon disulfide.

A solution of one drop of the oil in 1 cc. of chloroform, when shaken with one drop of sulphuric acid, acquires a light violet color, changing to purple and finally violet blue or brown.

When equal parts of benzene and oil are centrifuged for 25 minutes at 25°C. no precipitate forms and a clear solution remains.

Table I presents the specific gravity, refractive index, cold test, free acid, non-saponifiable matter, saponification value and iodine value for the liver oils of sand shark, lemon shark, dusky shark, and fo r"Shark Liver Oil—Shark Industries" (blended oil).

TABLE I.—Tests and Standards for Shark Liver Oils as Determined by Methods in the United States Pharmacopeia XI.

	Sand Shark	Lemon Shark	Dusky Shark	"Shark Liver Oil—Shark Industries" (blended oils)
Specific Gravity 25° C.	0.918	0.921	0.919	0.917-0.923
Refractive Index 20° C.	1.4758	1.4769	1.4759	1.475-1.480
Cold Test				
Clear	35° C.	35° C.	35° C.	45° C.
Cloudy	10° C.	10° C.	10° C.	15° C.
Free Acid	0.1 c.c.	0.2 c.c.	0.1 c.c.	0.1 c.c.-0.3 c.c.
Non-Saponifiable Matter	3.13%	2.94%	3.13%	3.00%-6.00%
Saponification Value	172	172	171	170-187
Iodine Value	145	143	125	125-145

[7]*Pharmacophia of the United States of America.* Eleventh Decennial Revision. (Prepared by the committee of revision and published by the board of trustees, Mack Printing Co., Easton, Pa., 1930-1940).

It is observed from the table that the specific gravity of the oils ranges from 0.917 to 0.923 at 25°C. The refractive index is from 1.475 to 1.480 at 20°C. The cold test shows that the oil becomes turbid at about 15°C., but becomes fluid and clear at 45°C.

Free acid test. Florida shark liver oil requires 0.1-0.3 cc. of tenth-normal sodium hydroxide for neutralization. The amount of unsaponifiable matter is not less than 2.94 per cent nor more than 6.00 per cent. The saponification value is not less than 170 nor more than 187. The iodine value is not less than 125 nor more than 145.

SUMMARY

Tests and standards by the methods in the U.S.P. XI for shark liver oil from sharks caught in Florida waters are presented.

CHEMICAL INTEGRATIVE MECHANISMS IN INSECT SOCIETIES

E. Morton Miller
University of Miami

In the maintenance of any organism a basic problem is that of communication among its parts and the coordination of the responses of those parts to provide a unified, adaptive behavior of the whole. The same problem exists to some extent for populations of organisms, particularly those which we designate as social.

The manners in which this problem of integration is solved by both single organisms and social populations show certain parallels. In fact, the remarkable similarities existing between the coordination phenomena in a single organism and those within a population of social animals have led various authors to the concept of the supraorganism or epiorganism (Wheeler, 1911; Gerard, 1940; Emerson, 1939). It is now possible, in the case of vertebrate animals, for us to describe to some extent the mechanisms which regulate growth and interaction among the body tissues, but less progress has been made in the analysis of integration within such supraorganisms as ant, bee, and termite colonies.

The purpose of this paper is not to expand upon the concept of supraorganism. The main attempt is to review knowledge and hypotheses regarding chemical exchanges among the members of insect colonies and to suggest the importance of these contacts as integrative stimuli which weld into a supraorganismic unit the many smaller units of the colony.

As pointed out by Child (1940) the organization of either cellular or organismic units into larger categories may involve two types of transmission of stimuli: one type is the transmission of energy and the other the transmission of materials. The present review is concerned with the latter mode of integration. Great gaps in knowledge will be obvious, but it is hoped that calling attention to these deficiencies may encourage investigation in the field.

An ant or a bee colony acts as an organized machine, exhibiting some efficiency in locating food, defending itself against unfavorable factors, and in maintaining its size by reproduction of needed units. Part of this organization apparently revolves around a communication system in which chemical materials are transmitted.

In ant colonies a consideration of chemical coordination naturally falls under two headings: first, the part played by recognition odors in regulating the behavior of the units of the colony and in maintain-

ing the closed society; second, the possible influence of special foodstuffs on polymorphism. Both of these aspects obviously are concerned in the pattern of division of labor which must exist in the colony if it is to act as a supraorganism.

Wheeler (1928) has summarized most of the observations in this group, drawing largely on others for experimental data. In spite of the difficulties of analyzing animal sensations through observations of reactions, Fielde (1904, 1905) came to the conclusion that

> besides discerning the aura of the nest and other local scents and the track laid down by its feet, an ant perceives in other ants: 1) the *incurred* or incidental odor which appears with changing conditions and disappears in course of time; 2) the inherited odor derived from the queen-mother and apparent in the eggs, larvae, pupae, and newly hatched young, and probably strengthening as size increases through the three inert stages of development; 3) the *progressive* odor that distinguishes the worker and changes or intensifies with her advancing age; and 4) the *specific* odor which pertains to the species or tribe.

This system of odors was inferred after a series of experiments in which individuals were transplanted from one group to another of known species and group experience. In connection with this hypothesis it was necessary to assume a considerable conditioning or memory ability for the ants.

The system described by Miss Fielde meets the communication requirements within each colony and automatically differentiates with age from that in other colonies—even groups of the same species. The dependence of ants on this integrative system was demonstrated by Fielde (1903) by amputation of certain antennal segments and their perceptors. Ants usually antagonistic may thus be made to live together by destroying the loci of colony odor sense, or by isolating individuals as callows before they were conditioned to a specific colony odor. The location of perceptor organs was as follows in Fielde's work:

1)	nest-aura sense	11th	segment	of	funicle
2)	colony-odor sense	10th	"	"	"
3)	individual-track sense	9th	"	"	"
4)	inert-young odor	7th and 8th	"	"	"
5)	odor of enemies	5th and 6th	"	"	"

Since Fielde's study, Schneirla (1938) has shown that the rhythmical integrated activities of *Eciton hamatum* colonies are regulated by a chain of factors among which chemical stimuli play an important part. Chemical and tactual stimulation from full-term pupae and callows within the bivouac excite a general movement eventually leading to the raiding system and to nomadism. A new developing brood of larvae is an excitatory factor in maintenance of

the raiding system once it is underway. Later work by the same author (1940) shows that in *E. burchelli*

> the form of communication which prevails is markedly dependent upon the workers' topo-chemical sensitivity . . . . In a setting of Eciton chemical the activities of one individual tactually influence other individuals and give rise to liaison devices which underlie group coordination. In the Ecitons such influences are "releasers" and definitely not language symbols, since any effects upon other individuals are incidental so far as the originator is concerned.

The characteristic differences in raiding pattern (hence integrative behavior) between the two species seem to depend on differences in amount and nature of the chemical released by the raiding workers, or on differences in chemical acuity in the two species. *Hamatum* shows more precise following of trails than *burchelli.* In addition to the chemical differences there may be, of course, other factors such as differences in rebound reaction and in general excitation threshhold.

The exchange of secretions and exudates further organizes and regulates the activities within the ant colony. These materials, unfortunately, have not been analyzed, but numerous students of ants seem to agree on the importance of such substances in group economy. Most interest centers about the possible influence of secretions and regurgitations on polymorphism and caste differentiation. Wheeler's (1928) term "trophallaxis" is applied to this system, in which the materials are exchanged by licking.

Numerous ant larvae possess large salivary glands and exudatory appendages—particularly in early stages—and all larvae seem to exude through their thin chitin fatty or lipoid films. Adult nurses apparently utilize these substances; furthermore, much mutual licking seems to go on among the adults of a colony. Direct evidence on the regulatory effect of this trophallaxis is largely lacking, but assuming, with Wheeler, that in many ant societies hunger is an imminent factor and that every source of nutriment must be exploited to preserve a rather precarious economy, then the possible bearing of trophallactic activities on caste differentiation may be surmised. This idea, coupled with recent emphasis on the concepts of threshold and of excitatory substances in development, provides a framework on which to construct various hypotheses (Whiting, 1938).

> The intimate dependence of the differentiation of queen and worker castes on food is beautifully shown in the growth of Aculeate colonies that are established by single queens. The first brood always consists of small workers, those of succeeding broods gradually increase in size, and only after the larger workers have appeared are queens produced (Wheeler, 1928).

Pricer (1908) followed such a sequence in *Camponotus pennsylvannicus*. Furthermore, any disturbance of the trophic balance by parasites within the colony (Lomechusini, for example) may, in certain types, produce pseudogynes and mermithergates as abnormal departures from the typical caste pattern. The insertion of these social parasites into the ant colony and their exploitation of a part of the nutritive juices seems analogous, according to Wheeler, to the absorption of body juices by internal parasites of single metazoan animals and their effects on life history seem similar (Wasmann, per Wheeler, 1928). On the contrary, certain intermediate forms like macrergates are produced under exceptionally favorable conditions of nutrition.

Myrmecologists have been much confused over the problem of caste regulation and differentiation, noting the sort of facts just mentioned, and yet feeling that most ants are so omnivorous in their food habits that any sort of regularity of caste differentiation based on a quantitative or qualitative nutrition basis is difficult to conceive. It remained for Pickens (1932), Heath (1931), and Castle (1934) to suggest the idea of inhibiting hormone secretion as an effective factor in caste regulation. This was done for termites and will be described later, but Robert Gregg (MSS., thesis) has used the concept in explaining results obtained in experimental colonies of the ant, *Pheidole*. In colonies composed only of soldiers and larvae, the development of further soldier forms was inhibited, while in controls composed of normal ratios or of workers only, soldiers continued to develop from the undifferentiated brood. This type of observation and the hypothesis of inhibiting hormone it implies helps to correlate some of the phenomena of caste regulation and trophallactic behavior and is, of course, a perfect example of integration of supraorganismic structures through chemically specific materials.

Among the circumstantial evidences for chemical integration one of the best examples is in connection with the symphiles, or true guests, which exist not only within ant colonies but also among termites. These guests, far removed taxonomically from their hosts, depend for their continued existence on the integration of their chemical exudates and odors with those of the social insect group. The species specific relationships and the special structures such as trichomes, exudatoria, or physogastric abdomens which are developed in many are morphological indications of the importance of secretions in adapting the guests to host tolerance and thus making the trophic and larval resources of the colony available to them (Warren, 1919; Wheeler, 1928). It is important to note, too, that according to Wheeler, the most specialized and numerous symphiles are to be encountered among the most highly socialized species of ants and termites.

Among social insects the honey bee, *Apis mellifera,* appears to be unique in its manner of colony founding and structure, new colonies being started by a single fecundated queen and a number of her worker daughters. The integrative mechanisms within the colony, however—like those of ants—deal with recognition, communication, and caste regulation.

Von Frisch (1927, 1938) seems to have the most complete descriptions of the communicative systems in the colony and has conducted numerous series of experiments which verify his observations. In brief the system works like this: when scout bees, flying from the hive and searching the surrounding area, locate nectar or pollen sources, they return to the hive and stimulate other workers by the so-called "dance" behavior; the nectar source is indicated by the flower scent adhering to the scout bee's body and also by scent-gland odor left on the flower at the original visit by the scout bees. The scent of dorsal glands of the worker bee is said to have an important orienting effect in the field. The numbers of collecting bees participating at a given time is automatically regulated by the amount of nectar available; as it diminishes the "dancing" stimulus decreases. If different plants are blooming, the flowers with the sweetest nectar cause the most vigorous "dancing." In this food collecting activity the essential factors in the integrative system are: 1) properties of the bee's body in absorbing specific odors; 2) the dorsal scent-gland; 3) the ability of the bee to become conditioned to colors and odors; 4) the nervous reaction which attracts attention in the hive.

Within the colony there are additional instances of the importance of chemicals in the form of odors. According to Phillips (1928) "every colony has a distinctive odor by which the bees recognize individuals from their own group, normally resenting the entrance to their hive of those from other colonies." Beekeepers in practice circumvent this specific colony recognition and unite small colonies by obscuring both colony odors with smoke. During egg laying, as the queen progresses over the comb, workers turn toward her when she gets within about half an inch, and hence she is always surrounded by a crude circle of workers facing inward. "This is probably a response to the stimulus of odor."

During cluster formation at swarming time the first bees to alight expose the dorsal scent-gland and "it seems probable that the odor which is emitted and dispersed attracts the flying bees to the cluster."

> In a large apiary where swarms are issuing frequently many swarms will settle on one particular support. The . . . . explanation for this . . . is that the support retains an odor acquired from contact with the swarm which acts as an attraction to other bees in act of swarming. (Phillips)

But other authors suggest that sight and the convenience of the support's location may be playing a part in this phenomenon.

> Von Buttel-Reepen (1900) . . . . concludes that there are seven normal odors which influence behavior in a colony: 1) an individual odor; 2) an odor common to the offspring of one queen; 3) brood and larval food odor; 4) drone odor; 5) wax odor; 6) honey odor; 7) hive odor, which is part or combination of all the other odors. (Phillips)

McIndoo adds queen odor and pollen-carrier odor. It is commonly understood that a new queen cannot be safely liberated within a colony until she has acquired the colony odor. These authors do not mention any progressive alteration of the individual odors with age, as was assumed for ants, but no doubt some changes could result through changes in quantity of brood, honey, etc. The workings of such a system within the bee and ant supraorganism remind one of the phenomena of tissue specificities and immunity reactions in the organism.

In the regulation of castes within the colony, chemical materials seem to be concerned. While the drone bee in its development seems directed largely by genetic factors, the differentiation between fertile queens and sterile workers appears to be environmentally induced. Bee naturalists have long maintained that larvae which were fed royal jelly throughout life became queens, whereas those deprived of the jelly and fed only pollen and honey after the second day became workers. Klein (1904) showed experimentally that the lability of the larvae is lost as time proceeds. If a larva one and a half days old is transferred from a worker cell to a queen cell (where it gets royal jelly only) it becomes a "perfect queen." Larvae transferred a day later are not quite typical queens in structure. With larvae fed in worker cells four and one-half days a distinct approach to worker type was obtained.

Royal jelly is said to be a salivary secretion (Nelson and Stutevant, 1924; Lineburg, 1924) although King (1933) maintains that the evidence for this belief is incomplete; other glands, mandibular, thoracic and post-cerebral may function during the time of larval feeding. King, furthermore, failed to note any true trophallaxis between workers and larvae; food and secretions were placed beside the larvae and not given directly. But Lineburg indicates that with older larvae, at least, the usual method of feeding is mouth to mouth and that reciprocal feeding is not an impossibility. Recently, various biochemical studies have been made on royal jelly in an effort to discover the essential factor in production of queen characters. Haydak and Palmer (1940) state that royal jelly exhibits "vitamin B_1 activity . . . equal to about nine gamma of thiamin chloride per gram of dry matter."

This is about one-third more than that found in "bee bread." Hill and Burdett (1932) suggested the presence of vitamin E in royal jelly but Mason and Melampy (1936) could not confirm this. Heyl (1939) advances the possibility that there is a gonadotropic hormone present, as a result of the precocious development he saw in graafian follicles of young mice which had received extracts of royal jelly. This is an interesting suggestion in view of the recent discoveries of the part played in insect physiology by hormones from corpora allata and other cerebral tissues (Wigglesworth, 1939).

Some agent stimulating ovarian hypertrophy is clearly indicated in the situation; the queen develops more rapidly after the third day and emerges with well-developed ovaries, but morphologically more degenerate than the worker in respect to head and tongue, wing, hind leg, and salivary gland development. Ovaries of many social insects (ants, bees, termites) are plastic organs which react with acceleration or retardation to trophic stimuli early in larval life (Ezhikov, 1923).

The secretions of workers in the honey bee hive appear to have a still further adaptive effect in connection with swarming. According to Morland (1930) the production of brood food by recently emerged nurse bees in excess of hive requirements stimulates building of queen cells and subsequent swarming. Morland analogized the case to that of excess "endocrine" in altering behavior of the organism. The brood-food excess naturally occurs soon after the peak of spring egg laying and, while it may be an important factor, numerous beekeepers have found it necessary to consider also factors of temperature and crowding within the colony in an attempt to solve the problem of colony budding.

Thus, among the bees, differential feeding appears to be an important regulatory and coordinating mechanism, although we cannot yet specify in precise chemical terms the nature of the materials involved.

The important coordinative effect of chemical materials in the termite supraorganism may be encountered as one reviews the general ontogeny and maintenance of colonies.

Soon after the alates swarm from a colony in their dispersal flight they shed their wings, and an assorting of males and females into pairs may be observed. The males are apparently attracted to females by odor. In *Reticulitermes* the sense organs for detecting the odor seem to be located in the eighth to the tenth antennal segments and the termite's behavior depends on symmetrical stimulation of these regions. Abnormal results (asymmetrical following) may be produced by injury to these segments on one side of the male. Males of *Coptotermes* appear to be able to orient to females three feet away

(Emerson, 1933). With *Kalotermes tectonae* the tandem behavior seems not to have been observed; instead, when alighting the sexes separately seek entrances in dead branches, there shed the wings, and then take up a "typical calling attitude in which obviously a perfume is spread . . . . Specimens of the other sex approaching the spot are strongly attracted" (Kalshoven, 1930).

Such integration of behavior via odors extends from this early beginning throughout the life of the colony. The medium of odor, here as among ants, is a recognition and communication mechanism. The chemical response can best be seen along trails of some of the foraging species, where each individual "follows the one in front through all the devious curves of the course, no matter whether several feet of space may separate them" (Emerson, 1929). Furthermore, in a migrating colony of *Nasutitermes costalis* the termites were accompanied by seven species of termitophiles, apparently responding to odor factors within the colony. Andrews (1911) in observing *Eutermes ripperti* (?) in Jamaica, noted certain reactions that indicated the existence of special colony odors. The movements of a single termite on a floor were random, but when several were present they soon followed in trailing fashion. Old trails were not followed as rapidly as recent ones. New objects, such as a sheet of paper across an established trail, caused interruption of the termite traffic. Likewise, the scraping-off of the surface of a board—along which a trail ran—stopped for a time the stream of termite travelers.

Individuals removed from one colony and introduced into another were usually killed or mutilated, although very young individuals were said to be an exception to this practice. Termites washed in water were given an abnormal reception by their own colonies and also by alien colonies, but were not always attacked. Specimens dipped in washings from many alien termites were apparently received as aliens in their home communities and as fellows in the alien colonies! Andrews noted considerable variation in the response between alien colonies; he does not state quite clearly whether he was comparing other species with *E. ripperti* or just different colonies of the one type. Nevertheless, there seems to be ample evidence of the part played by volatile chemicals in binding together individuals of each colony. But the colony odors seem to be easily obscured; Victor Dropkin and others have been able to mix different species and genera of Kalotermitidae by treating both with anesthetic or by introducing both to new, neutral substrata.

The young nymphs which first hatch in the incipent colony are unable to utilize wood at once and must be fed by secretions from the parents (Pickens, in Kofoid et al., 1934). Neither wood par-

ticles nor protozoa are present until the second or third instar; in *Prorhinotermes simplex* occasional second instar individuals are found with protozoa in the hind gut, but these do not seem to be common. Even after utilization of wood begins on the part of young nymphs the reception of various secretions from the reproductives continues and the reciprocation in secretions begins, so that a tightly constructed system of trophallaxis is established. The theoretical and actual effects of this exchange of secretions seem quite numerous. On the one hand, the feeding of the reproductives by the nymphs ("workers") facilitates especially the general nutrition of the queen, aids hyperthrophy of her ovaries, and reduces her to complete dependence on her offspring because of the gradual degeneration of her mandibular muscles. According to Kalshoven the number of eggs laid by the queen increases with the growth (and presumably the nutritive contributions) of the colony. (This is in line with Pricer's observations on the ant, (*Camponotus.*)

On the other hand, certain secretions from the reproductives influence the development of nymphs of the colony. This idea was first specifically verbalized by Heath(1907, 1931) and Pickens (1932) although practically implied years ago in the findings of Grassi and Sandias (1896-97) and in the studies by Jucci (1926). Satisfactory experimental evidence was then collected by Castle (1934). Welding together the pertinent contributions of these various workers we seem to have the following picture: the presence of functional reproductives of either frist, second, or third forms inhibits the reproductive potentialities of all nymphs which receive in effective dose certain secretions from the reproductives. The secretions are sex specific, see mto be of the nature of hormones, may be extracted from the reproductives by alcohol or ether, and are effective when fed orally via filter paper (in *Zootermopsis* at least). It is possible that the hormones originate in the corpora allata and are transferred, via the haemolymph, to the fat bodies and hypodermis, where they are picked up by nymphs grooming the reproductives (Light, Hartman, O. H. Emerson, unpublished MSS). Obviously, as the population of the colony grows larger the grooming opportunities by each nymph (hence hormone dosages) grow less, and so some nymphs may push on to reproductive, and sometimes winged, development. Not only does the removal of functional reproductives from experimental colonies allow the development of supplementary reproductives, but in nature large colonies may possess more than one pair of functional reproductives (Grassi; Heath, Harvey, in Kofoid et al., 1934). Frequently the extra supplemental pairs are at some

distance from the heart of the original colony and the original reproductives.

This situation reminds one of that noted by Witchi (in E. Allen, 1932) in his studies on parabiotically-twinned frogs. A "sphere of influence" decreasing in effect with distance from the center appeared to exist around the developing gonads, and if the gonads of the sex slower in development (female) lay within this sphere of influence their normal direction of development was altered or inhibited.

But this regulative effect is not confined to the reproductives. There are indications in Castle's work that soldiers, likewise, exert an inhibiting effect on the development of soldier potentialities in the undifferentiated nymphs. The evidence for this is not yet as clean-cut, however. Soldiers continue to develop in the new colony, even after the appearance of the first, and in small laboratory groups of *Prorhinotermes* the presence of a few soldiers does not absolutely inhibit the development of others. In the latter care, however, it may be that the original ratio of soldiers to nymphs was too low to obtain observable inhibition. A tendency towards regulation of soldier-worker ratio seems to exist in various species: in *Kalotermes flavicollis* the ratio was about 1:5-6; in *K. tectonae* about 1:10, in *Prorhinotermes simplex* about 1:3.5-4. But the "sphere of inhibition" exerted by soldiers would seem to be more restricted than in case of reproductives, or else there are other factors involved. Grassi noted that if too large a number of soldiers were added to a nest many were killed or eaten. In my observation, they simply may be neglected and starve.

Thus there appears in the literature ample suggestion of a chemical integrative system as important in the ontogeny and behavior of the social insect colony (the supraorganism) as is the hormone system to a vertebrate individual, and having in some cases, perhaps, certain analogous characteristics. Now the most necessary observations that need tob e made center around chemical analysis of the regulative substances that seem to exist. It is of interest, also, to know whether such hormones as postulated by Castle are species specific.

Further study of coordination mechanisms in all animal groupings should be encouraged in order to enlarge our philosophical understanding and to suggest principles for human social organization. An understanding of insect social organization is of interest to us humans who have just begun our evolutionary history, comparatively speaking, and who have a long way to go in the matter of group integration.

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SOLUTION A DOMINANT FACTOR IN THE GEOMORPHOLOGY OF PENINSULAR FLORIDA

SIDNEY A. STUBBS
Florida Geological Survey

Through the eyes of the geomorphologist, Florida is nearly level when compared with many other sections of the United States. The highest measured elevation in Peninsular Florida, Iron Mountain on the property of the Mountain Lake Corporation, near Lake Wales, is only 324.3 feet above sea level. Higher elevations are claimed for some nearby hills but no accurate figures are available. By the standards of many parts of the country this is indeed a very low hill. This stress on slight elevations and flat topography has been carried through various text books and popular publications into all parts of the country. Even today there are millions of people who picture Florida as a flat plain broken by swamps and lakes that are teeming with alligators, exotic birds and a profusion of tropical plants. To those who live in Florida, or have visited it, the above is an entirely erroneous picture.

Cooke[1] has designated five main physiographic divisions for the State: the Coastal Lowlands, the Central Highlands, the Tallahassee Hills, the Marianna Lowlands, and the Western Highlands.

The Coastal Lowlands border the entire state as a belt around the coast from the Georgia line at the St. Mary's River to the Alabama line at the Perdido River. For the most part elevations in this division are well below 100 feet and Cooke[2] states that the inner edge generally lies at the 100 foot contour. The Central Highlands is that part of the State familiarly known as "The Ridge." It is a conspicuous feature from the Georgia line south to just below Lake Istokpoga where it drops abruptly into the Coastal Lowlands. The Tallahassee Hills adjoins the Central Highlands to the west and extends to the Apalachicola River. The Marianna Lowlands extends westward from the Apalachicola River in a roughly quadrilateral area in Holmes, Jackson and Washington Counties. The Western Highlands division borders the western edge of the Marianna Lowlands and extends westward to the Perdido River. A narrow belt bordering the Marianna Lowlands to the Apalachicola River is also referred to the Western Highlands. The Central Highlands and the Tallahassee Hills are sim-

[1]C. Wythe Cooke, *Scenery of Florida* (Fla. Geological Survey, Bull. No. 17, 1939), p. 14.
[2]*Ibid.*, p. 15.

ilar geologically and topographically. In this paper the discussion will largely be confined to these two areas.

Anyone driving south from Lake City to the southern tip of the Central Highlands through Gainesville, Ocala, Leesburg, Groveland or Orlando and Polk County is impressed by the dissected topography and the large number of lakes. Yet streams, which are usually the foremost agent in producing such dissected topography, are conspicuously absent. If one goes south through Orlando he crosses only one stream of any consequence, the Santa Fe River just north of High Springs. In going south through Groveland toward Lakeland, the Santa Fe River and the upper reaches of the Withlacoochee just north of Eva are crossed. Since it is obvious that surface streams are playing small part in shaping the landscape, we must wonder, then, what forces have carved the numerous valleys we traverse.

TABLE 1
GEOLOGIC FORMATIONS OF FLORIDA

Age	Formation		Lithologic Character
Pleistocene	Terrace Deposits		Sands, pure and argillaceous, non-calcareous.
	Melbourne Bone Bed		Sands, clays, carbonaceous material.
	Ft. Thompson Formation	Probably time equivalents	Indurated shell marl, quite sandy.
	Anastasia Formation		Coquina.
	Miami Oolite		Very sandy, oolitic limestone.
	Key Largo Limestone		Almost entirely coral.
Pliocene (?)	Charlton Formation		Sandy marls, impure limestone, and clays. Known only along the St. Mary's River.
Pliocene	Alachua		Hard rock phosphate, sand, clay.
	Bone Valley Gravel		Pebble phosphate.
	Citronelle Formation		Sands, gravels and very argillaceous sands.
	Caloosahatchee Marl	Probably time equivalents	Highly fossiliferous, sandy, shell marl.
	Tamiami Limestone		Sandy, impure limestone (indurated marl).

TABLE 1—(Continued)
GEOLOGIC FORMATIONS OF FLORIDA

Age		Formation		Lithologic Character
Miocene	Alum Bluff Group	Buckingham Limestone	Probably time equivalents	Impure limestone known only from the vicinity of Buckingham, Lee County.
		Choctawhatchee Marl		Highly fossiliferous marls and clay; in places quite sandy.
		Shoal River Formation		Sandy shell marls.
		Oak Grove Sand		Sandy shell marls.
		Chipola Formation		Shell marl, indurated marl and impure limestone.
		Hawthorn Formation (In part equivalent to Oak Grove and Chipola Formation)		Highly phosphatic sands, clays, marls and sandy limestone.
		Tampa Limestone		Limestone, very irregular and nodular in character; in places containing much silica.
Oligocene		Suwannee Limestone		Limestone very similar to the Tampa Limestone but high in magnesium in places.
		Byram Marl		Cream colored to yellow sandy limestone.
		Glendon Limestone		Yellow, impure, fossiliferous limestone.
		Marianna Limestone		Usually pure, white, soft limestone.
Eocene		Ocala Limestone		Pure, cream to white limestone. Texture variable, very hard to very soft. Almost never crystalline.
		Coskinolina Zone*,†		Cream to brown, often dolomitic, in places hard and crystalline limestone. Gypsum crystals present.
		Dictyoconus Zone*		Like the Coskinolina Zone but more dolomitic and largely recrystallized by solution. Gypsum crystals common.
		Borelis Zone*		White, buff, and brown, usually hard, fine grained limestone. Sometimes chalky; often recrystallized; frequently gypsiferous; some anhydrite.

TABLE 1.—(Continued)
GEOLOGIC FORMATIONS OF FLORIDA

Age	Formation	Lithologic Character
Upper Cretaceous*	Ripley/Selma	White to gray, fossiliferous chalk. Lower part marl, shales and sands.
	Eutaw	Clays, sandstones, micaceous shales.
	Tuscaloosa	Clays, shales, sandstone. Shales reddish to very dark.
Middle Cretaceous*	Reported in two wells in Florida. See: Robert B. Campbell, "Deep Test in Florida Everglades," *Amer. Assoc. Petroleum Geologists Bull.*, Vol. 23, (1939) pp. 1713-1714. — — — "Outline of the Geological History of Peninsular Florida," *Proc. Florida Academy of Sciences*, Vol. 4, (1940) pp. 95-97.	
Older Formations*	Black shale, metamorphic and igneous rocks. The age of these has not been settled. See: Herman Gunter, "Basement Rocks Encountered in a Well in Florida," *Amer. Assoc. Petroleum Geologists Bull.*, Vol. 12, (1928) pp. 1107-1108. C. Wythe Cooke and Stuart Mossom, "Geology of Florida," *Florida Geological Survey Twentieth Annual Report*, (1929) pp. 44-45. Robert B. Campbell, Op. Cit. pp. 91-96 — — — "Paleozoic under Florida?" *Amer. Assoc. Petroleum Geologists Bull.*, Vol. 23, (1939) pp. 1712-1713.	

Not recognized in Peninsular Florida.

*Not exposed at surface in Florida.

†In this paper the term Coskinolina Zone is retained although the author realizes that revision of the name applied to this zone is necessary. At present, however, there are not sufficient data available to satisfactorily revise this terminology and it seems desirable to retain the old name rather than clutter the literature with new names.

A brief review of the geologic formations of Florida will make the following discussion clearer. During the geologic past Florida has

stood below the level of the sea many times and during those periods the sediments making up the various formations were accumulated. Table 1 has been compiled from recent literature and records in the office of the Florida Geological Survey. This table brings up to date all information on the geologic formations known to be present in Florida. From the table it can be seen that throughout much of pre-Tertiary and all early Tertiary history, the sediments deposited were high in calcium carbonate, the mineral constituent of pure limestone. Two factors largely account for this condition. The source material for sedimentary rocks was far to the north and only those materials held in solution by the sea water would be carried as far south as Florida to be deposited. Calcium, which is precipitated as calcium carbonate, is the most plentiful mineral carried in that manner. The early Tertiary seas of Florida being warm and shallow were conducive to the deposition of lime. This lime with the addition of millions of tests of various marine invertebrates, which are also of calcium carbonate, formed hundreds of feet of almost pure limestone. During later Tertiary times the sediments were less calcareous but still contained a high percentage of lime. It is only in the last geologic period, the Pleistocene, that we find an absence of calcium in the sediments of the central part of the state. These sediments are largely unconsolidated sands that freely absorb all the rain that falls on them.

The thickness of the limestone deposits of Florida has been determined in a number of deep wells that have been drilled as tests for oil in various parts of the state. In a well drilled to a depth of 6,180 feet near York in Marion County, there are 3,370 feet of limestones. In Nassau County there is a 3,170 foot section of limestones shown in a well drilled there. In a recently completed well carried to a depth of 10,006 feet in northeast Monroe County, 9,550 feet of limestones were encountered and the drill was still in a calcareous formation when the well was abandoned.

All limestones are soluble to some degree in ordinary ground waters. The solubility depends upon the hardness of the limestone, the permeability of the rock and the degree to which the ground water is charged with acids. The various acids present in the ground water that tend to dissolve the limestone are largely derived from the decomposition of organic matter, principally vegetable. In a warm, damp climate, organic matter decomposes rapidly. The profuse flora of Florida, part of which is dying at all times, thus daily liberates an enormous amount of acid-forming gases. Carbonic acid (H_2CO_3) is

the most active agent in the solution of limestone. This acid forms and reacts as follows:

$$\underset{\text{Water}}{H_2O} + \underset{\text{Carbon Dioxide}}{CO_2} = \underset{\text{Carbonic Acid}}{H_2CO_3}$$

$$\underset{\text{Carbonic Acid}}{H_2CO_3} + \underset{\substack{\text{Calcium}\\\text{Carbonate}\\\text{(Limestone)}}}{CaCO_3} = \underset{\text{Calcium Bicarbonate}}{Ca(HCO_3)_2}$$

Pure water dissolves calcium carbonate in a ratio of about 1 part in 30,000 by weight. In waters carrying dissolved CO_2, however, the carbonate is changed to the bicarbonate as shown in the above formula. The bicarbonate is about 7 times as soluble as the carbonate. In addition ground waters probably contain small amounts of acetic acid and propionic acid derived from the decomposition of certain plants. Acetic is a particularly active acid and may play an important part in the solution process. Decaying organic matter also yields considerable hydrogen sulphide (H_2S). Since this gas is slightly soluble in water, large quantities eventually reach the underground formations. These same waters carry varying amounts of free oxygen and this may oxidize the H_2S thus forming sulphurous acid (H_2SO_3), which would act as a solvent for the limestone in the following manner:

$$\underset{\substack{\text{Hydrogen}\\\text{Sulphide}}}{H_2S} + \text{Oxidation} = \underset{\substack{\text{Sulphurous}\\\text{Acid}}}{H_2SO_3}$$

$$\underset{\substack{\text{Sulphurous}\\\text{Acid}}}{2\,H_2SO_3} + \underset{\substack{\text{Calcium}\\\text{Carbonate}\\\text{(Limestone)}}}{CaCO_3} = \underset{\substack{\text{Calcium}\\\text{Bisulphite}}}{Ca(HSO_3)_2} + \underset{\substack{\text{Carbonic}\\\text{Acid}}}{H_2CO_3}$$

Acid-charged ground waters are therefore continuously entering our limestones, and part of the limestone is being carried away by these same waters which are eventually discharged through springs. These springs are found both on the land and in the ocean at varying distances from the coast. One of the best known submarine springs along the Florida coast is the large spring just off shore from Crescent Beach, St. Johns County. It has been reported that in the days of sailing vessels boats would put in at some of these marine springs to replenish their fresh water supply. The Florida Geological Survey has, however, been unable to obtain a sample of fresh water from these springs.

The importance of solution was recognized by Sellards[3] in the first bulletin published by the Florida Geological Survey. He listed seven

[3]E. H. Sellards, *A Preliminary Report on the Underground Water Supply of Central Florida,* (Fla. Geological Survey Bull. No. 1, 1908), pp. 46-57.

springs and gave the amounts of solids removed by each per day. On the basis of an estimated annual intake and outflow of waters in the limestone formations, he estimated that the general surface of Florida was being lowered at the rate of about one foot each five or six thousand years.

The chemical load carried by various springs in the State reaches a staggering figure. It is true that such data are more qualitative than quantitative because of the many variables involved; but the figures illustrate the erosional force of percolating ground waters. In Table 2, the chemical load of various Florida springs or spring systems has been computed from the figures collected by the United States Geological Survey and the Florida Geological Survey. All of this chemical load was picked up by ground waters from the rock and soil through which it passed, and nearly all of this material is being carried directly into the ocean. The load shown by these figures is based entirely upon solids carried in solution. In addition, underground waters carry a load of undissolved solids that are directly resultant from solution activity. Limestones dissolve unevenly and produce a honeycombed rock. In places the solid portions of such rocks are very thin, and in underground streams and near spring outlets portions of undissolved rock are carried away by the freely moving waters. This action adds considerably to the erosion effects of solution. It is therefore evident that even though no other processes were involved, the degradation action of percolating ground waters would alone be sufficient to greatly modify the surface of the earth.

Reference has previously been made to the fact that all present land surfaces of peninsular Florida were at one time the ocean floor, which was essentially flat. When this floor was elevated above sea level the land surface formed was a flat one. This surface has since been modified by weathering processes and structural deformation. Ordinarily we think of weathering as a phenomenon taking place on the surface of the earth. Normal topography is developed by the action of surface streams, winds, ice and waves tearing down and carrying away the surface material. All of these have played their part in shaping the surface of Florida; but these factors have been subordinate to underground solution. The entire region designated as the Central Highlands is a striking example of solution topography.

The first step in the modification of the landscape by solution activity is the formation of a sinkhole. In an area where the limestone is exposed, this is evidenced on the surface by a straight-sided, round, chimney-like depression. In a region where the limestone is covered by a thickness of sand and other unconsolidated sediments the sinkhole assumes the shape of a large funnel with rather steeply sloping

TABBLE 2

DAILY DISCHARGE AND LOAD IN DISSOLVED SOLIDS OF SOME OF FLORIDA SPRINGS

Name of Spring	County	Total solids parts per million	Measure discharge in gals. per day	Solids removed per day in short tons
Silver	Marion	284	531,012,000 Dec. 30, 1898	628.80
			219,932,000 Feb. 27, 1917	260.40
			885,456,000 Jan. 8, 1934	1048.62
Blue (Rainbow)	Marion	83	502,588,000 Dec. 22, 1898	188.01
			466,748,000 Feb. 21, 1917	161.36
			529,136,000 Oct. 6, 1937	182.92
Itchatucknee	Columbia-Suwannee	211.6	118,332,000 Feb. 19, 1917	104.38
			124,162,000 Oct. 25, 1937	109.52
Weekewachee	Hernando	173	93,670,000 Feb. 23, 1917	67.60
			149,226,000 May 6, 1931	107.76
			105,944,000 Oct. 12, 1937	76.50
Wakulla	Wakulla	167	67,830,000 Aug. 14, 1931	47.31
Salt	Marion	5,210	52,584,400 Apr. 10, 1930	1143.03
			57,817,000 Feb. 10, 1931	1256.77
Poe	Alachua	204	55,556,000 Feb. 19, 1917	47.70
White	Hamilton	203	46,512,000 Feb. 13, 1907	39.10
Suwannee	Suwannee	220	28,424,000 May 17, 1906	26.37
DeLeon	Volusia	1,256	23,040,000*	120.60
Sulphur	Hillsboro	619	22,610,000 Feb. 24, 1917	14.70
			37,080,400 Oct. 18, 1933	95.74
Kissengen	Polk	232	13,566.000 Feb. 25, 1917	13.13
			14,987,200 Oct. 14, 1937	14.50

*Estimated flow.

sides. The mechanics of sinkhole formation is simple. As mentioned above, moving ground waters are continuously carrying away a small portion of the limestone. This solution activity is most pronounced in the softer rock because the soft rocks are much more permeable and therefore a greater volume of water is moving through the rock. The hard rocks may contain more pore spaces but the transmissibility is low and solution is slower. Inasmuch as no limestone bed is uniform in hardness and density, certain portions are more susceptible to solution than others and these portions are dissolved more rapidly. In time an underground cave or channel is formed. For a long time the roof of this underground channel or cavern is strong enough to support the overlying load; eventually however, the roof is dissolved away to such an extent that it becomes too weak to carry the load and collapses. This is evidenced on the surface by a sinkhole.

If the sink is deep enough to reach below the zone of saturation, it will be water-filled and in time it may be enlarged to lake size. All the lakes through the ridge section of peninsular Florida are of sinkhole origin. Even the largest lakes such as Orange Lake in Alachua County, Lake Apopka in Orange County, Lake Iamonia in Leon County, Lake Weir in Marion County and Alligator Lake in Columbia County, are essentially of sinkhole origin.

The formation of these lakes was complex, many weathering agents contributing, but there is no doubt that underground solution was the dominant factor. Each of these lakes originally consisted of one or more sinkholes. Surface waters flowed into these sinks and in time a surface stream probably formed. This stream may have eventually connected with another sink or a stream leading into another sink. After a long time these two streams, or one stream as the case may have been, cut down to a depth where the two sinks were connected and an elongated lake was formed. This might conceivably involve a number of sinks situated rather closely together thus forming a large lake with several arms. At the same time, the increased flow of surface waters into the sink would accelerate the solution of the limestone into which they were flowing. This increased solution activity would cause the formation of many sinkholes in that limited area and greatly extend the size of the original lake.

The famous disappearing lakes of Florida were formed in such a manner. These disappearing lakes are all without surface drainage, but drain through one or more sinks directly into the underlying limestone. The mechanics of the disappearance of these large bodies of water is of interest. The bottoms of the lakes stand below the ground water table during normal and rainy seasons. In excessively dry seasons the permanent ground water level drops perceptibly. At first

LAKE [illegible] [illegible] [illegible] [illegible]

[illegible]

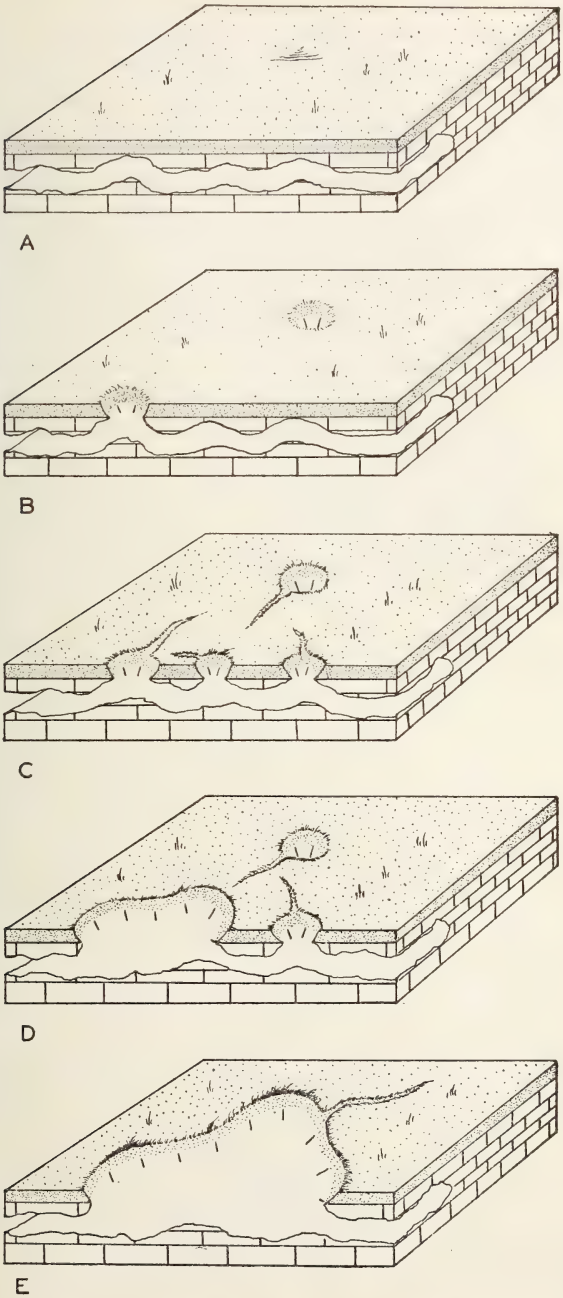

FIG. 1 STAGES IN THE FORMATION OF A SOLUTION LAKE BASIN

the lowering of the lake level is not noticeable. As the lakes become contracted in size, however, the drop in the lake level becomes increasingly more noticeable until in the last stages it seems to disappear overnight. One of the best known of these capricious lakes is Lake Iamonia north of Tallahassee.

In times past Payne's Prairie just south of Gainesville was such a lake. Until 1891 a river steamer did a thriving business carrying freight on Alachua Lake from Gainesville to Orange Lake. Disappearing lakes such as this operate somewhat differently from lakes such as Iamonia. The floor of this type of lake is above the permanent ground-water table. If the sink through which the area is drained becomes plugged, the waters back up and form a lake until such a time as the plug may break and allow the water to be drained normally. In the beginning, however, these lakes probably operated in the same manner as Lake Iamonia, but a permanent lowering of the ground-water table has brought about the present condition.

We ordinarily think of solution as taking place at and above the permanent ground-water table. Whether or not this is true is subject to some debate. Davis[4] has written a rather extensive paper attempting to point out that the very nature of vadose waters is not conducive to extensive solution of limestone to form caverns. The majority of writers have, however, held to the first mentioned premise. In truth it would seem that caverns are formed both above and within the zone of saturation. Percolating waters move downward rapidly above the zone of saturation and then are slowed and diverted laterally at that point. This being true the most active solution should be at this point. We must remember, however, that in Florida our underground waters are in motion, even though this motion is slow, and that the water will dissolve the rock through which it is passing. It is therefore reasonable to believe that solution is taking place throughout the limestone section to the depth, if such depth exists, at which the waters are stagnant. It is even reasonable to believe that the solution by volume is greater within the zone of saturation than above, because the waters are moving slowly and therefore act more completely on the limestone.

When considering the action of underground waters as an agent in shaping and lowering the general surface level, we must also remember that the surface formation in Florida during the geologic past has been different at various times. It is known that the Ocala limestone was raised above water and extensively eroded before the deposition of the younger formations. The same may be said of almost

[4]W. M. Davis, "Origin of Limestone Caverns," *Bull. Geol. Soc. of Amer.*, Vol. 41 (1930), pp. 475-628.

all the formations of different ages now exposed in the State and in my opinion the same is true for older buried deposits. During these periods of emergence the limestone formations were being acted upon by surface waters and solution was taking place. In the case of the Ocala limestone a much larger area was exposed above sea level than is exposed now. Large limestone springs and sinks developed. Solution channels were formed. During the time of the next submergence and emergence cycle the surface sinks and perhaps some of the superficial underground channels were filled, but the deeper of these remained open and their development continued throughout the succeeding geologic ages.

The Pleistocene period is considered a period of greatly accelerated solution activity in Florida. With the formation of the great polar ice sheets enormous volumes of water were withdrawn from the sea and the sea level dropped several hundred feet below the present level. In contrast the highest exposed land stood far above the present maximum elevation. This condition allowed the formation of extensive systems of solution channels and caves in the limestone. When the sea again rose, these channels and caves were flooded by an elevated ground-water table and became underground rivers.

Unfortunately the entire peninsula of Florida has not been mapped topographically. Topographic sheets are available, however, for most of the area in which the Ocala limestone is exposed. A critical examination of these sheets will show many interesting solution features and some of these deserve special mention. On the Arredonda sheet, which includes Gainesville and vicinity, a number of lakes and prairies are shown. Payne's Prairie is the most conspicuous feature on the sheet. The history of this prairie has already been discussed. Sanchez Prairie, which is very similar to Payne's Prairie, is partially shown in the northwest corner of the sheet. This prairie stands about forty feet higher than Payne's Prairie and may be somewhat older. Its floor is largely sandy loam and for many years much of it has been farmed. Muck soils are absent. This would indicate that Sanchez, unlike Payne's Prairie, was never a lake, at least for any length of time. The lowering of the area was accomplished in a like manner but drainage underground has been continuous.

Hogtown Creek draining into a sink at the southwest corner of Hogtown Prairie very clearly illustrates the manner in which a stream will develop from a sink. Hogtown Prairie with Lake Kanapaha adjoining it to the south is a sinkhole basin. The sink into which Hogtown Creek drains also drains Hogtown Prairie and Lake Kanapaha. Hogtown Creek is the largest stream that has developed from the

sink, but there is a short unnamed creek cutting almost due north, and wet-weather drainage is developed into the sink from the west. That last-mentioned arm is cutting toward a sink about three miles away and will probably eventually connect the two basins. Hogtown Creek has developed a rather steep valley to the northeast and a tributary of the creek has cut a similar valley northwestward. This arm is working toward the headwaters of Blues Creek which drains into a sink in Sanchez Prairie. In time this arm will probably capture the headwaters of Blues Creek and ultimately divert the drainage of that higher area into Hogtown Prairie. Hogtown Creek proper has now worked back to the vicinity of Paradise.

The Ocala and Williston sheets both show the extent to which small sinkholes have influenced the topography in regions of exposed limestones in the State. With the exception of very short streams draining into sinks, the Williston sheet shows no surface drainage. The terrain, however, is rugged, having elevations ranging from 170 feet above sea level to less than 60 feet above sea level. The Ocala sheet shows a similar condition. The famous Silver Springs in the extreme eastern portion of the area has given rise to the only large surface stream. Elevations in the area covered by the Ocala sheet range from 180 feet above sea level to less than 60 feet above sea level. A total of 397 sinkhole basins is shown on the Ocala sheet. These basins range from very small, typical sinkholes to large depressions formed by the connection of several sinks.

The famous limestone springs of the State, of which Silver Springs is the largest, if not the largest of its kind in the world, are solution phenomena. The flow of these springs usually issues from a number of sinkholes of the round chimney type. Cooke[5] has explained these springs as being sinkholes of rather recent origin the mouths of which lie below the present artesian water level or piezometric surface.

The Tsala Apopka and Panasoffkee sheets illustrate a peculiar type of solution topography. In the vicinity of Tsala Apopka and Panasoffkee lakes, the piezometric or artesian water level stands between 30 and 40 feet above sea level. The Withlacoochee River drains the surface waters of that area, and has cut down to below 40 feet on the eastern side of Tsala Apopka Lake. This necessarily means that springs have developed in the river and that in that area underground solution has been greatly accelerated. This has led to the formation of a chain of sinkhole depressions of various sizes, all of which reach below permanent water level. The myriad of islands noted in Tsala Apopka Lake are portions of the old land surface left standing as the surrounding land has been lowered by underground solution.

[5]*Op. cit.*, pp. 88-89.

FIG. 2. PORTION OF THE INTERLACHEN QUADRANGLE SHOWING LARGE NUMBER OF SINKHOLE LAKES

The Interlachen Quadrangle illustrates the nature of sink depressions in a region where the limestone is covered by a considerable thickness of sands and clays. The surface formations in the Interlachen area are sands and slightly argillaceous sands. These are underlain by the clays, marls and limestones of the Hawthorn Formation. Under such conditions the ground-water level lies near the surface of the ground and is above the artesian water beds which are confined below the clays and marls of the Hawthorn Formation. This water line conforms roughly to the general contour of the land. We therefore find that nearly all the sinkhole depressions of such an area will form a lake. On the western half of the Interlachen sheet 298 lakes of all sizes are shown that are definitely of sinkhole origin. These lakes and the conditions shown on that portion of the Interlachen sheet are very similar to those of Orange, Polk, Lake, Highlands, and the southern part of Marion Counties.

Striking examples of the effectiveness of underground solution as an agency in shaping the surface features are to be noted in other parts of the State. Between Greenville and Madison and to a lesser degree from Madison to the Suwannee River the land is predominantly rolling. The valleys are relatively deep with sloping sides and the hill tops are usually quite flat. This same character of topography extends northward for some distance and southward to the Gulf Coastal lowlands near Perry. A few small surface streams have been developed, but most of the area is drained underground. Apparently this whole area has been shaped by underground streams that empty into the Suwannee and Aucilla Rivers.

Similar topographic features are to be seen between Wellborn and Lake City. There are numerous steep-sided sinkholes, lakes and round bowl-shaped valleys in this vicinity. A particularly noticeable feature is a rather large dry lake about 5 miles west of Lake City. This is part of a solution basin that extends over a rather large area and is roughly elongate north and south. In times of very high water in the Suwannee River this area has been known to be flooded by waters backing up from the river.

The Santa Fe River which rises in Santa Fe Lake and empties into the Suwannee River south of Branford traverses an area that has been greatly modified by the action of underground waters. At Alachua Sink this river leaves its surface channel and continues for some distance through a tortuous underground course. The path of this stream underground can be clearly traced by a series of natural bridges shown on aerial photographs by a succession of sinkholes.

There are numerous large springs feeding into the river from Santa Fe Sink until it empties into the Suwannee River.

Many of these springs have developed channels and now form short streams. The Itchatucknee River emptying into the Santa Fe River just south of Hildreth is entirely a spring-fed river. Its head is Itchatucknee Springs, the third largest measured spring in Florida. All along the course of the stream, however, there are large and small springs feeding into it. This river is probably the surface expression of a longer underground stream. It has developed by a successive cutting back through the formation of sinkholes and large springs along its course. There is some evidence that at one time the Itchatucknee may have extended farther north, and that this northward extension went underground some distance above the present spring. If this is true the drying up of this more northern stream may be accounted for by a drop in the permanent artesian head of the waters in that area. There is considerable evidence that such must have occurred in the case of some short tributaries of the Santa Fe just west of High Springs. There are two very distinct stream channels, now dry, in that area. These were spring-fed and the old spring mouths are still clearly evident, but the artesian head has now dropped too low for these springs to flow.

The surface features of Lake County, the western half of Orange County, and much of Seminole County are the result of underground drainage and solution. This part of Florida is justly proud of its numerous lakes. These lakes are apparently all of sinkhole origin. Numerous round sinkhole basins are to be noted. One of the most striking of these is passed through just east of Mount Dora on the road leading to Sanford. The floor of this basin is almost flat. In general outline it is almost circular and its sides are quite abrupt. The development of a similar basin may be noted on the southern outskirts of Apopka. Here there are two sinkholes so closely adjacent that they have coalesced to form one large circular depression. One of the sinks extends slightly deeper than the other and is a very small permanent lake. The other is a lake only during wet weather. Lake Jessup, now an arm of the St. Johns River in Seminole County is one of the most eastern of the large sinkhole lakes in this area. The sink character of this lake has been determined by a study of deep wells along its shore. The amount of casing necessary to penetrate the Ocala limestone abruptly increases very greatly around the shores of the lake. A dry basin that was in the past a similar lake is the Slavia drainage district just south of Oviedo in Seminole County.

The lake region of Polk and Highlands Counties is similar to that of Orange, Lake and Seminole Counties, but here the covering of sandy materials is greater and the sinkholes seem to be much deeper. Some of these sinks extend to almost incredible depths below the surface. In one well drilled just north of Haines City, casing was carried to a depth of 900 feet without penetrating limestone. Ordinarily the wells in that area have less than 400 feet of casing. The ground elevation at the well probably does not exceed 175 feet. The sinkhole, therefore, extends to at least 725 feet below sea level and perhaps to a much greater depth.

Many of the sinks in the Polk County section are not evident on the surface. This is due to the fact that there is a much greater covering of loose material and the sides of the sinks have rapidly caved. This coupled with the fact that these sediments are easily transported by weak winds has tended to cover many of the smaller sinks in a short time. One of the most striking of these deep, funnel-shaped, sinkhole lakes of this area is situated at the southern outskirts of Haines City. From a rather high elevation, the sides slope very abruptly down for over 100 feet. The road from Haines City to Lake Wales goes through this sink.

In the coastal areas the effect of solution upon the topography is not as pronounced as in the higher lands. These areas have only recently been elevated, and the effect of the planing action of waves, to which they have recently been subjected, is the most pronounced surface feature. The nature of the sediments, however, is conducive to very rapid solution and the results of such action are already evident. This is particularly true in the region from Brevard County northward. The surface formation is usually unconsolidated sands and immediately below these sands there is a considerable thickness of sandy, highly fossiliferous shell marls. Rain water is readily absorbed by these sands and marls and as readily given up wherever the marls outcrop, particularly along the St. Johns River. This means that there is a free movement of water through the formations and that the shell material is being carried away rapidly. In some places shell material constitutes as much as 75 per cent of the formation. Where this is true sinkholes are likely to form frequently. Many sinkhole lakes and depressions are to be seen between Sanford and Palatka and much of the relief in Volusia and Putnam counties is attributable to solution. Relic dunes and bars are the only other conspicuous surface features. Surface erosion has as yet played little part in shaping the land of this area.

From Lake Okeechobee southward through the Everglades and along the East Coast from Ft. Lauderdale into the Keys, pot holes are a conspicuous surface feature. A pot hole is a solution feature, but differs from a sinkhole in that the solution action is taking place on the surface. These are usually rounded, sharp-sided depressions varying in size. The formation of pot holes depends upon the formation exposed on the surface. In the Everglades this formation is the Tamiami limestone or the Caloosahatchee marl which in that area is usually indurated and very similar to the Tamiami limestone. Along the East Coast, the exposed formation is the Miami Oolite and in the Keys the Key Largo limestone. These formations are all irregular in character and present an uneven surface. Rainwater that is not immediately absorbed by the rocks accumulates in the depressions. These small pools of water take minute amounts of the rock into solution and when the water is finally absorbed by the formation the depression has been deepened by that amount. The extremely high rainfall of southern Florida and the rank vegetation combine to hasten the formation of these depressions. A counterpart of these pot holes can be seen in the quarries in Central Florida where the Ocala limestone is being mined. The pot holes in these quarries formed during some past geologic age and have since filled with sand and clay. This clay must be cleaned out ahead of quarry operations, and in some places the number of such clay pockets has been so great that the expense of cleaning these pockets has forced the operators to abandon the quarry.

From the preceding it is evident that in humid regions where the geologic formations are predominantly calcareous, many of the surface features are attributable to solution activity. This is strikingly true in Florida. Other physiographic features have received more detailed treatment by the various workers who have written on the geomorphology of the State. They are, however, more evident to the trained than to the average observer. Those features that strike the layman are almost entirely the result of the action of percolating waters and underground solution.

HEAVY MINERALS IN THE BEACH SANDS OF FLORIDA

WILLARD B. PHELPS
University of Tampa

The work of analyzing the beach sands of Florida for their heavy mineral content has been undertaken by the Department of Geology at the University of Tampa as a part of their research program. This project is a continuation of J. H. C. Martens' work on heavy minerals of Florida (which appeared in the Nineteenth Annual Report of the Florida State Geological Survey in 1928). Our study includes many new localities on the beaches of peninsular Florida, as well as the localities studied by Martens. Our object is to determine the distribution, relative amount, approximate size, and source of these heavy minerals.

Selected samples of beach sands containing heavy minerals were taken from thirty-five localities and carefully analyzed and studied. The heavy minerals were separated from the sand samples by using a heavy liquid such as bromoform or Thoulet's solution (potassium mercuric iodide), which has a specific gravity slightly over 3. These minerals are called "heavy minerals", because they have a greater specific gravity than quartz, the predominant constituent of sand. The heavy minerals under consideration have specific gravities well above 4, while quartz has a specific gravity of 2.65. Thus, the heavy minerals sink to the bottom of the solution, while quartz and other lighter minerals float on the top.

The heavy minerals include ilmenite, a titanium iron oxide; rutile, a titanium oxide; zircon, a zirconium silicate; and monazite, a phosphate of the cerium metals, and usually includes some thorium oxide. Some other minor heavy minerals found in the beach sands are garnet, epidote, tourmaline, and staurolite. It has been found that ilmenite, a black mineral, is the most abundant of the heavy mineral group and therefore, the name "black sands" has been given to these concentrations. The heavy minerals in the order of their abundance in the beach sands of Florida are shown in Table I.

TABLE I
PERCENTAGE OF HEAVY MINERALS AFTER DEDUCTING QUARTZ

Mineral	West Coast	East Coast
Ilmenite	44	42
Zircon	26	13
Rutile	10	26
Monazite	15	14

The heaviest concentrates found were at Jacksonville Beach on the East Coast and at Venice, Indian Rocks, and Dunedin beaches on the West Coast, as shown by Table II.

TABLE II

PERCENTAGE OF HEAVY MINERALS IN SAND

Localities	
Fernandina	2.5
Jacksonville Beach (concentrate)	25.0
St. Augustine	2.0
Daytona Beach	1.5
Ft. Pierce	2.5
Miami	1.8
Dunedin	7.0
Clearwater	3.0
Indian Rocks Beach	10.0
Anna Maria	4.0
Venice	13.0

Most of the concentrations are of small areal extent and shallow depth and therefore are not of commercial importance at the present time. All of the beach localities sampled, however, showed a small amount of all four of the heavy minerals.

Relatively simple and rapid means can be used in identifying these minerals in most cases. Ilmenite is usually equidimensional and shows a moderate degree of rounding. It is easily identified by its black color and its brilliant luster. Zircon is generally colorless and is slightly elongated showing its prismatic habit. Many of the zircon crystals are vertically striated. Rutile is dark reddish-brown to light brown in color, with a tendency toward slight elongation with rounded ends. Monazite is pale greenish-yellow and is very well rounded. It is somewhat softer than the other heavy minerals and is worn down much easier. The degree of rounding is indicative of the distance that the minerals have been transported. Thus, these minerals seem to have been transported from moderate distances, only a few hundred miles. Many of the mineral grains are frosted, which means that they have been subjected to wind abrasion.

It was noted in studying the heavy minerals from Jacksonville to Miami, that the concentrates in the northern part of the east coast were much smaller in diameter than those to the south. The minerals averaged 0.1 millimeter in diameter in the Jacksonville area and gradually increased in size southward to Miami, where they averaged 0.2 millimeters in diameter. It is possible that the waves washed the finer materials further up on the beach during severe storm periods

and therefore, out of reach of the ordinary waves and longshore currents. The larger minerals, due to their greater weight, were not carried so far up on the beach and thus could easily be moved southward by normal waves and longshore currents.

Many people think of heavy minerals as being rare, but actually they are common constituents of most sands. Many analyses of beach sands and sandstones show the presence of heavy minerals in small amounts. Large commercial concentrations of these minerals are rare, however, and Florida is one of the few places where they are found in even moderate concentrations. These minerals are foreign to this State. They are found originally in igneous rocks such as granite, syenite, and diorite. The rocks of Florida are entirely sedimentary, which means that they were formed from pre-existing rocks. The source of these heavy minerals is the crystalline rocks of the Piedmont in Virginia, North Carolina, South Carolina, and Georgia. The rocks of the Piedmont are known to contain many localities of these particular minerals. For example, ilmenite is particularly abundant at Ashland, Virginia, and in Ashe, Caldwell, and Mitchell Counties of North Carolina and parts of South Carolina; zircon is found at Ashland, Virginia, and in Henderson and Madison Counties of North Carolina; rutile is particularly abundant in Amherst and Nelson Counties of Virginia, Alexander and Clay Counties of North Carolina, and Graves Mountain in Georgia; and monazite from Amelia Courthouse in Virginia and a score of counties in North and South Carolina.

These minerals are weathered out of the rocks by atmospheric agencies and are removed by the action of streams flowing from the Piedmont down across the coastal plains to the ocean. Such streams as the James River in Virginia, the Roanoke and the Neuse Rivers in North Carolina, the Peedee and the Santee Rivers in South Carolina, the Savannah and the Altamaha Rivers in Georgia, and the Chattahoochee River in Florida are instrumental in bringing these minerals to the ocean. Then through the continued action of longshore currents, tides, and storm waves the minerals have worked their way slowly southward. This method of transportation has taken thousands of years, probably millions of years, to bring these heavy minerals to the shores of Florida. Nevertheless, this same method of transportation is still in active operation today.

Then through the agency of storm waves and, to a slight degree, wind, the heavy minerals are concentrated in the sands of the beach in layers or strips. This method is quite similar to the concentrating of gold, tin, and platinum in the gravels and sands of streams. These deposits are known as placers, and therefore, the heavy minerals of Florida can be called "beach placers". The concentrations are

more pronounced on shores which are being actively eroded, such as Jacksonville Beach and Venice. Whereas, the shores which are being built up have only slight concentrations.

Heavy minerals are also found in the sands of the central ridge section of Florida and around the shores of many of Florida's lakes. Two outstanding examples are worthy of note: (1) heavy minerals were found in the Haines City well samples down to a depth of 140 feet, which is definitely within the Pliocene epoch; (2) and heavy minerals were also found in the well samples of the Peninsular Oil and Refining Company's J. W. Cory No. 1 well in Monroe County near Pinecrest down to the depth of 400 feet, which according to paleontological evidence is well within the Miocene. This latter information was obtained while studying the sedimentary petrology of the samples, which were kindly given to the University of Tampa by Mr. Robert B. Campbell, President of the Peninsular Oil and Refining Company. The heavy minerals were well scattered in the two wells, there being no concentrations. This evidence merely shows that the heavy minerals of the Piedmont were being brought into Florida by streams and ocean currents millions of years ago, just as they are today.

The uses of ilemite and rutile, both compounds of titanium, are in alloys such as titanium bronze and steel, white pigment in paint, and in the manufacture of titanium tetrachloride which is vital in warfare for such purposes as smoke screens, tracer bullets, and gas offense. Zircon is used in refractories, in making opaque white enamels, special alloys, zirconium-nickel cutting tools, optical glass, aeroplane motor spark plugs, and electrical resistance units. Monazite is of minor importance, being one of the sources of rare earths, of which cerium and thorium are used for gas lighters and cigar lighters.

The emergency use of these minerals is possible in the manufacturing of certain defense materials. The heavy minerals of Jacksonville Beach, which is the heaviest concentrate known in Florida, have been successfully worked in the past. Therefore, it is possible that impending conditions and new methods of recovery might make these beach sands of Florida profitable and useful. The work on this project has not been fully completed as yet. There are many more localities in peninsular and northwest Florida to be sampled and studied. Larger concentrations, more economical methods of recovery, and increased demands can make the heavy minerals of Florida commercially important to the State.

PETROLEUM EXPLORATION METHODS

Robert B. Campbell
Tampa, Florida

References in the Bible and in scattered works of other ancient authors show that oil, gas, asphalt, etc., have been used by man since the earliest days of his history. Oil was discovered in Baku in the tenth century, the Chinese were drilling oil and brine wells 2000 feet deep hundreds of years ago, and by the middle of last century many countries—Poland, Roumania, Russia, France, Burma, Argentina, Venezuela, Colombia,—had had petroleum activities of one sort or another. On the southern margin of the Wietze field the State of Hannover completed a successful well in 1858 which is producing periodically today. Nevertheless, the petroleum industry may be said to date from the completion of the Drake well at Titusville, Pennsylvania, when Colonel Edwin L. Drake, a former railroad conductor, brought in his well August 29, 1859, at a depth of sixty-nine feet. It was completed as a twenty barrel pumper and is generally regarded as the starting point of the industry.

The story of the modern oil industry may be divided into three periods, the first, from 1860 until 1900, during which petroleum was used principally as a source of illuminating oil; the second, beginning with the advent of the automobile and ending with the World War when, as Lord Curzon put it, "The Allies floated to victory on a sea of oil"; and third, from that date to the present.

During the first period shallow wells in the eastern part of the United States and in Europe produced enough oil for the illumination and lubrication needs of the world, with the price of oil remaining rather uniform at about 90 cents per barrel. Exploration was carried on by following creek courses, apparent trends of production, and topographic features similar, real or fancied, to those in some producing area. It was during this period, however, that the anticlinal theory was developed by T. Sperry Hunt and E. B. Andrews independently, though many of the fundamental facts had been pointed out earlier by Henry D. Rogers, a professor of Natural History at the University of Glasgow. But although Hunt first propounded this theory in 1861 it seems not to have been put to practical use until about 1884 when I. C. White used it in exploratory work. Hunt, White, and Rogers had all been employed on the Geological Survey of Pennsylvania where they and their colleagues first enunciated many of the fundamental theories of petroleum geology.

During the second period, when the total crude oil production rose from 63,620,000 barrels per year in 1900 to 265,763,000 in 1914,

the dominant method used in oil exploration was the search for favorable surface structure. The use of this method began about 1910 and reached its maximum between 1920 and 1925, since when it has declined steadily until today it represents a small part of the effort expended in oil exploration.

The third period, from the time of the First World War to the present, saw production mount to 770,874,000 barrels in 1926 and to about 1,250,000,000 for this year. In contrast to the first period when the principal demand was for kerosene, at present the yield of kerosene from crude oil is only about 5.6%. The yield of gasoline today is about 44.1%, of fuel oil 25.3% and of gas-oil 13.0%. Other figures concerning the petroleum industry are of interest. The percentage of total water and mineral fuel power in the United States supplied by petroleum has increased from 7.7% in 1899 to between 40% and 50% today. This last statement is based on the fact that, though 86% of the total installed horsepower, including automotive units, is dependent on petroleum fuel, the mobile units are in operation only part of the time, therefore it is estimated that somewhat less than half the nation's power sources are supplied by oil as a fuel. Another figure-fact of interest is that the petroleum reserves in sight today amount to about eighteen billion (18,000,000,000) barrels or fifteen years' supply. This is in contrast to the coal reserve of two and a half trillion (2,500,000,000,000) tons or about five thousand years' supply at the present rate of consumption, which is slightly less than five hundred million (500,000,000) tons a year.

During this period the demands on the petroleum industry have been met by the exploration groups with the introduction of new methods as each earlier method exhausted its possibilities. About 1920, when all the surface structures apparently had been discovered, structure hunting began to be based on the myriad data supplied by existing bore-holes with contour maps drawn on datum points in wells. About 1923 physical measurement of earth characters, generally called "Geophysics", was first applied to exploration for oil in America when the torsion balance was introduced into the Gulf Coast Area, its first success being the location of the salt dome at Nash, Texas, in 1924. Since that time geophysical exploration has grown in method and technique until today it is the most favored of exploration methods. About the same time the study of well cuttings expanded in scope until it is possible to postulate what have come to be known as "stratigraphic traps." The newest development in oil discovery is "geochemical surveying" or "soil-gas analysis" which, although at present it can count only two discoveries to its credit, promises much for the future of exploration for petroleum.

Nevertheless, it should not be inferred from the foregoing that oil is discovered only by the means listed above. Random drilling based on hunches, local pride, dreams, even astrology, or for no discernible reason whatever, has each had its share of success. F. H. Lahee has addressed his attention to this for the last few years and has published some interesting statistics. Defining a wildcat as any well drilled outside the boundaries of developed production he shows that in 1939 there were 1563 wells drilled in the United States on such geological techniques as mentioned above, of which number 217 were successful and 1,446 dry, or a record of about 13% successes. Of 872 wells drilled without benefit of professional advice only 43 were completed as producers, and of the remaining 217 classified as "for reasons unknown" only 10 were successful. These last two classifications grouped together show a record of about 6% successful. Other figures by Lahee are of interest. He shows that 10.43% of all holes drilled and 12.87% of the footage drilled was productive. The average depth for wells for 1939 was 3,331 feet, although the record drilling depth is 15,004 feet in a California well and the record depth of production is 13,266 feet in a south Louisiana well.

Concerning the number of geologists giving their attention to oil exploration the following figures are of interest. The American Association of Petroleum Geologists has nearly 3500 members and the American Institute of Mining and Metallurgical Engineers lists about 2000 members in its petroleum division. Though these membership lists overlap to a great extent, the duplication is probably offset by the number of geologists who are not registered in either organization, and it seems safe to estimate that at present over 5000 men and women are applying themselves to petroleum geology in this country. In American universities this year more than 2500 students are majoring in geology. Figures for the last few years indicate that about 250 geologists enter the petroleum field each year. This is approximately one half of the total number of geology students leaving school each year.

THE ORIGIN OF PETROLEUM

Theories concerning the origin of petroleum are divided into two groups, inorganic and organic theories. In the first the formation of oil is believed to be due to the reaction of inorganic substances in the earth at depth. Such theories were formerly widely held by both chemists and geologists, but with the growth of knowledge of the geological conditions under which oil fields are found geologists have now practically abandoned the inorganic theories. These theories,

now almost exclusively the property of chemists, may be listed as follows:

1. Reaction of water containing carbon dioxide in solution with alkali metals under great heat and pressure.
2. Action of water or dilute hydrochloric or sulphuric acids on metallic carbides.
3. Action of volcanic gases on limestone.
4. From original hydrocarbons present in atmosphere early in earth history, stored in the core and later transferred to the outer layers.

To this group of theories is opposed the general idea that all important deposits of petroleum are found in unaltered sedimentary rocks, and that rare occurrences in igneous and metamorphic rocks are so associated with the sedimentaries that these latter must be reasonably regarded as the source. There are many different organic theories concerning the method of transformation of original source material into petroleum, but they may all be grouped into one broad theory that petroleum is derived from organic material buried in sediments. That there are many different theories based on this conception may be explained by the fact that there are many different substances under the name "petroleum."

ACCUMULATION OF OIL

The real problem for the petroleum geologist is to determine the location of oil pools, so his professional attention has been directed more to the problem of the accumulation of petroleum than to its origin. In the search for new petroleum provinces the matter of the origin of oil is of concern to the explorer, but once the existence of such a province is determined the geologist takes the presence of oil strata as established and bends his efforts to finding where the petroleum has been trapped.

Geologists divide rocks into three classes, igneous, sedimentary and metamorphic. The names indicate their origin, the igneous, including all rocks hardened from a previous molten state, the sedimentary, those transported and deposited by and in air or water, and the metamorphic, including rocks of the first two classifications altered by heat or pressure. Examples of the first are granite, lava, etc., of the second, limestone, sandstone and shale, and of the third, gneisses, marbles, quartzites, schists, etc. Oil only rarely and exceptionally occurs in the igneous and metamorphic rocks, leaving the petroleum geologist to confine his attention to sedimentary rocks.

Sedimentary rocks are originally laid down in approximately horizontal strata which are later warped into various attitudes due either

to tangential stresses or the differential settling of the upper layers over deep seated positive points. The first may be illustrated by the crumpling of a piece of paper, the second by the behavior of the upper crust on a green apple pie. For each structural area a regional slope

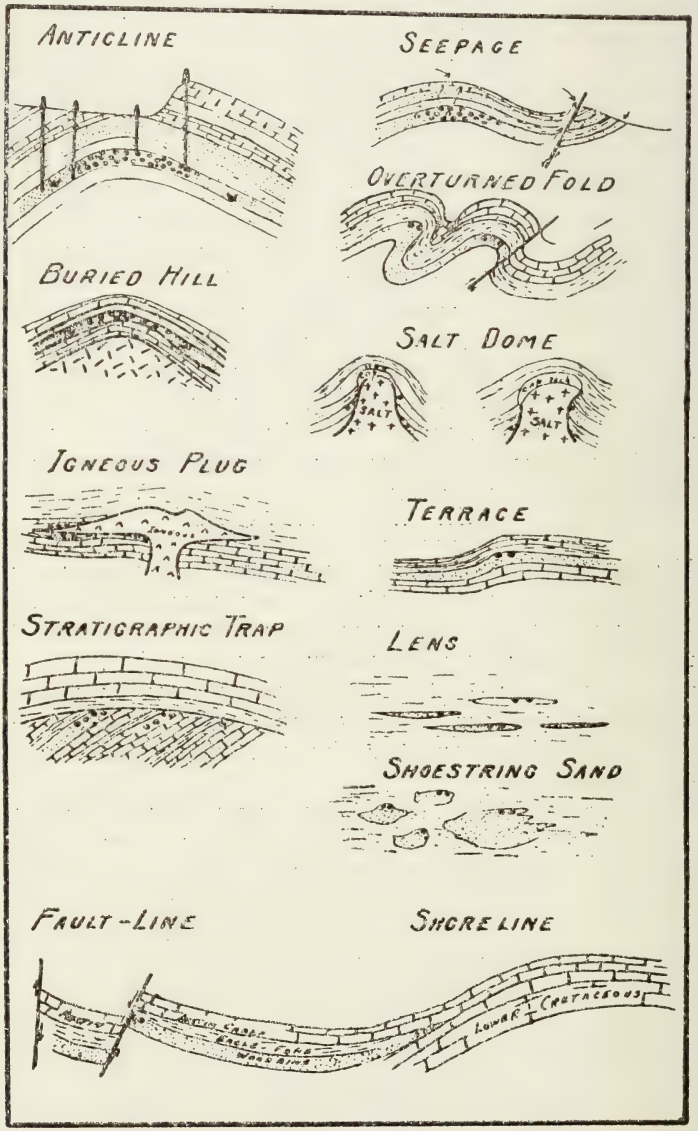

Fig. 1.—Diagrammatic Petroleum Traps

or dip, as the geologist terms it, is recognized and is known as the "normal dip" and variations from it as the "local dips." A dip in a direction opposite to the regional dip is known as a "reverse dip" or a "reversal." The direction at right angles to the maximum dip is known as the strike. Dip and strike are usually represented by a T-shaped symbol, the perpendicular line indicating the direction of the dip, the horizontal line representing the direction of strike. It is obvious that the strike is always horizontal and should coincide with the contour line at that point. A figure on the symbol represents the amount of the dip. Once the regional dip is established the geologist's task is to find variations from it.

An anticline is a structure in which the beds are so deformed that the strata are inclined against each other, the resultant structure being similar to an "A"-tent. For oil accumulation it is necessary that this structure be closed at the ends. If this closed structure is elongate it is termed an anticline and if it approaches a circle in ground plan it is known as a dome. The association of such structures with the occurrence of brine and oil was early observed in the field but the anticlinal theory as such rests on the recognition that most porous rocks are water-saturated at depth and that associated gas, oil, and water tend to separate according to their different densities. The separation of cream from milk is sometimes given as an illustration but the explanation is over simplified. Probably most geologists include some idea of flushing and in some quarters it is held that movement is involved wherein the grating of the sand grains liberates the oil film on the grain faces permitting its flushing, so that "cream separation" illustration seems inadequate. A better illustration is furnished by the methods pursued by the firty-niner "panning" for gold. In this process the prospector agitates his mixture of gold, sand and water until the gold, being heaviest, is concentrated in the bottom of the pan. By a similar method, but inverted and on a much grander scale in both time and space, Nature has segregated the oil and gas from the associated water and trapped them, the pans she uses being anticlinal structures. The accumulation of oil is not restricted to anticlines, however, but is apt to occur anywhere a porous horizon lies between two impervious layers, where some structural or textural condition halts the up-dip migration of the gas and oil buoyed up by the water. Such trapping may be accomplished by faulting, lensing, stratigraphic traps, differential cementation, or any combination of them.

The gas associated with oil in the underground reservoir occurs both as a free gas cap and as gas in solution in the oil. The amount

of gas in solution depends on the character of the oil and reservoir pressure and temperatures. In general, the pressure may be determined by assuming a pressure of 50 lbs. per square inch for each 100 feet of depth. Thus a well 10,000 feet deep would normally have a reservoir pressure of 5000 lbs. per square inch. This is termed rock pressure and has been assumed to indicate the weight of the overlying rock, but in most cases is due to the hydrostatic head of the water contained in the reservoir formation. This gas pressure is the dominant factor in efficient operation of oil properties and in the preservation of oil and gas resources. The dissolved gas performs a varied function in that it decreases the viscosity of the oil, reduces the surface tension on the faces of the sand grains, and furnishes the motive power to force the oil from the formation into the well and to the surface in flowing wells. All the efforts of petroleum engineers, either for oil operators or for state conservation administrators, are with the purpose of maintaining this gas pressure. To this end they use various devices, such as regulating well spacing, completion of wells, rates of withdrawal, and the amount of gas that may be expended to produce a given amount of oil. The last is what is known as the gas/oil ratio, and is held to as low a value as possible.

GEOLOGICAL METHODS

The attention of the geologist may be drawn to a new area because of paleogeographic studies or simply because of the known or suspected presence of beds that are productive elsewhere. If he has come because of non-geological reasons, such as at the behest of the land owners, promoters, or only out of curiosity, he must develop some theories for the area concerning its paleogeography or the possible existence of buried source and accumulation beds. His immediate work in the field is to determine the sequence of the strata and map them, noting the attitude of the beds. In hard rock country the dip may be everywhere visible, but in soft rock country his observations may be confined to railroad and highway cuts. Sometimes he resorts to digging test-pits or hand-augering in critical locations. His tools are a Brunton compass with clinometer, to measure dip and strike, a hand level, a pedometer if making a foot traverse or speedometer if working from an automobile, and frequently an aneroid barometer.

Shortly after the beginning of the second period as oil exploration moved into the mid-Continent area where many of the structures are of comparatively little relief, it was found necessary to improve on the work of the reconnaissance geologist. This was done by adopting the plane table as a more accurate means of mapping structures. The instrument man with his alidade mapped the location and

elevation of certain beds pointed out by the geologist acting as the rod man. One or more beds were used in this mapping and, when all were reduced to a common datum, contours were drawn to indicate the structure.

By the time of the World War it seemed that structures discoverable at the surface were becoming rarer and rarer. This, together with development of the idea that the closer the contoured horizon to the producing level the better the chance of accuracy and success, led to the use of data revealed in the drillers logs, of thousands of wells and, during the lustrum beginning in 1925, this method enjoyed considerable vogue and many wildcats were drilled on structures outlined by this means. Though today many such regional and field maps are kept up in a routine manner it is questionable if any significant number of wildcats is located by this means. However interest grew in the information yielded by bore-hole samples of the material drilled being examined until today the collecting of samples plays an important part in the drilling of all wildcats and many wells in proven fields.

Such samples of formations come in the form of both cuttings and cores. Although all early drilling was done with cable tools much of the world's drilling today is done with a rotary rig, especially when soft formations are encountered. In the first method the bit, suspended on a cable, is repeatedly lifted and dropped in the hole and pounds its way downward. Every five feet or so it must be withdrawn and a bailer lowered to clean out the hole and bring the cuttings to the surface. Though this method is not as efficient as may be desired from the operator's point of view, it does have the advantage of yielding plentiful samples from accurate depths and as the casing in such wells is usually closer to the bottom of the hole the samples are comparatively free from contamination with those from higher formations.

On the other hand the rotary type of drilling is more efficient from the point of view of the well driller but furnishes cuttings of less value than those from a cable tool hole. The rotary method consists of rotating a bit on the bottom of a long hollow drill stem through which muddy water is introduced under pressure to the bit where it is debouched, and then returns to the surface outside the drillstem. This mud stream serves several purposes in the drilling, such as washing the bit clean, cooling it, plastering the walls of the hole, holding back water or gas pressures, but the function that interests the geologist most is that it carries the cuttings to the surface. There the mud stream is poured through sluices or other devices to remove the cuttings and the mud is again forced down the hole. It is obvious that there are two disadvantages to this method of securing samples, first that there

must be considerable contamination of samples, and second that there is a difference between the time of cutting the samples and the time when they are recovered at the surface, so that the depth of the bit at that time is greater than when the samples were cut. Both of these disadvantages may be more or less satisfactorily corrected, but the most accurate method consists of taking cores. In this a special core bit is used cutting samples up to 20 feet or more in length from the bottom of the hole. When desirable these cores may be oriented as in their original positions. These cores furnish a clean sample from a precise depth but are rather expensive and since in deep wells it may take a full 24-hour day to recover a core, the cost may be $1,000 or more. A geologist demanding such cores must justify his curiosity with real results. There are also methods of taking cores from the sidewalls of the hole when such are needed after the bit has passed a critical horizon. The most spectacular of these consists of shooting a small core-barrel from a 45 calibre cartridge horizontally into the wall and retracting it with a spring. These cartridges are detonated electrically from the surface where through the calibration of the suspending cable an accurate control of depth is obtained.

These cores and cuttings are analyzed in the laboratory for characters that might prove critical for any reason but most important for those indicating a precise point in the stratigraphic column. Here they undergo a microscopic examination for fossils and minerals. There are today between three and four hundred men and women employed in such studies by the oil companies at an estimated annual cost of more than one million dollars. It is estimated that each worker requires an average investment of $2,000 in equipment.

Of the fossils studied the most important are the foraminifera, because their abundance and small size makes specimens plentiful in spite of the grinding and pounding of the bit, but other small fossils are sometimes used. At the risk of launching a controversy with partisans it may be stated that the relative importance of different types of fossils by eras is as follows:

PALEOZOIC — foraminifera, radiolaria, holothuria, mollusks, echinoid spines;

MESOZOIC — foraminifera, holothuria, radiolaria, ostracods;

CENOZOIC — foraminifera, ostracoda, mollusks, diatoms, fish remains, radiolaria.

Of course local conditions may make forms of fossils here regarded as less important more practical for use in particular districts. The main object of the paleontologist is to date the strata and correlate them

with others. This is a relatively simple matter for restricted areas but correlation on an inter-regional scale involves many variable factors. Practical paleontologists who, as indeed all explorers for oil, must be oriented to the area of their activities, may be very accurate in their work from well-to-well correlations but correlations over great distances can be attempted only by workers with broad training and experience.

Cores and cuttings are also examined for lithologic and mineralogic characters. Of course crushing, faulting, dip, unconformities or other such characteristics give evidence of the structure. Lithologic examination is interested in the type of rock, its texture, grain size and shape, banding, porosity, permeability, etc. In addition correlations are made on the basis of heavy mineral content. In this, heavy minerals are isolated in a bromoform solution and the grains examined for size, shape and by ordinary petrographic methods for mineral identification. Though there are definite geologic and geographic limits to this method it is of considerable value in formations barren of fossils or as a check where fossil evidence is unsatisfactory.

In the examination of cores from producing strata the emphasis is on the determination of porosity, permeability, and oil, gas or water content. These features indicate the nature of the reservoir and its probable yield. The porosity of commercial oil sands varies from 20% to 35%, making for a pore space of 1600 to 2700 barrels per acre foot. Due to the fact that water is always present in oil sands, and that dissolved gases and elevated temperatures at depth increase the specific volume of oil as measured at the surface, the oil content limit is reduced to about 1000 to 1800 barrels per acre foot. To the influence of the reservoir characteristics are added those of the oils themselves, the most important of which is viscosity, all of which control the recovery of oil. This recovery of oil ranges from 200 to more than 1100 barrels per acre foot, representing from 10% to 85% of the oil originally present in the reservoir. Figures for limestone reservoirs are less satisfactory than for those of sand, but may be said to vary within wider limits. With data such as these for a background, such examination of cores gives expectation figures for new fields.

Another method of determining the consistency or extent of induration of strata drilled is with a time log. This merely records the time necessary to drill short intervals. Such logs are simple and are easy to understand. Within limited areas such as a single oil pool they may be used in correlations with electric or sample logs.

GEOPHYSICAL METHODS

In many cases indications of structure at the surface are lacking

or do not truly reflect the structure at the expected oil horizons. Two striking examples of this condition are furnished in the Gulf Coast where young and little disturbed formations obscure the location of the salt domes around which the oil is accumulated and in Michigan and Illinois where several hundred feet of glacial till blankets the Paleozoic rocks which supply the oil reservoirs. Under some conditions core holes are drilled to determine structure by mapping key horizons, but usually such drilling is used as a means of checking areas already indicated as favorable by some geophysical survey.

Exploratory geophysics, employing sufficiently sensitive instruments, determine the variations of some physical properties presumed to indicate subsurface conditions and structure. The most important of these properties, magnetism, gravity, elasticity and electrical resistivity, form the basis of four major geophysical methods employed in geophysical exploration. While these methods may reveal the presence of specific minerals, in oil exploration such methods are confined to the search for suitable structure. It is important to note that neither geological nor geophysical methods furnish a direct means of discovering oil but search rather for conditions favorable for its accumulation. This statement should be qualified, however, by recognition that direct prospecting for oil may be accomplished through the more recently developed soil analysis or electrical resistivity methods. But though partisans claim much for these methods it cannot yet be said that they are established techniques.

The methods above mentioned may be divided into two classes: 1, gravitational and magnetic; 2, seismic and electric. In the first group the characteristics are inherent in the geologic bodies themselves and the operator is without depth control. This has been called geophysical "mapping". The second class where the energy is supplied artificially,—in seismic procedures by dynamite explosions, and in electrical methods where the energy is supplied galvanically or inductively,—may be termed geophysical "sounding", since the operator has a depth factor that may be read.

The magnetic methods, where applicable, are most useful for rapid reconnaissance. Although both horizontal and vertical magnetometers are used, the instrument most commonly used in America is the Schmidt-Askania which consists of a magnetic needle balanced horizontally on a knife edge and set at right angles to the magnetic meridian. The variation is measured in "gammas" and is presented for geological interpretation in various forms but most frequently in profiles and contour maps. In the latter the contour lines connect points of equal magnetic anomalies and are known as magnetic iso-anomalies.

The magnetic method was applied to the location of ore bodies as early as 1640 and is one of the oldest of geophysical methods, but in oil exploration in America its history dates back less than twenty years. Experience during that time shows it to be the fastest, simplest and least expensive of the geophysical methods. Since geologic bodies are usually strongly or weakly magnetic coinciding, for all practical purpose, exactly with the division of igneous and sedimentary rocks, magnetic surveys in oil exploration comprise mainly the mapping of buried hills of igneous or metamorphic rocks, or areas where magnetic sedimentary layers are uplifted. Another important application is the mapping of igneous plugs around which oil may have been trapped. This last is probably the only condition where locations are made on magnetic mapping. Usually the magnetometer is used for rapid reconnaissance to be checked or supplemented later by other geophysical methods. As accumulations about igneous intrusions represent a very small part of the earth's petroleum supplies it is obvious that the magnetometer of itself can not be credited with any substantial number of oil discoveries.

Another earth character that may be mapped is gravity. Its value in exploration is dependent on the differences in gravity between various geologic bodies. The most accurate method of measuring gravity is with pendulum instruments such as are used by the United States Coast and Geodetic Survey. The Survey has occupied over a thousand pendulum stations, of which 106 are located in Florida. However, though accurate, these pendulum instruments are unwieldly and are slow to set up and read and others of the same type designed for field work are impractical for exploration work. To meet such need more portable instruments—the torsion balance and the gravity meter or gravimeter—have been developed for commercial exploration. The torsion balance consists of a beam revolving in a horizontal plane and as read gives the results of the horizontal forces acting on it and shows the gradient of the change of gravity. However in the last five or six years it has been superseded by the gravimeter. This instrument in its simplest form consists of a mass suspended directly from a spring with arrangement for magnifying the displacement and means for reading. These instruments measure the pull of gravity in *gals,* a word which is a contraction, not an abbreviation, of Galileo, invented to honor his memory. The practical unit used in field measurements is a milligal. The claimed accuracy of these instruments is within .0002 gals. Anomalies of .002 or even less are enough to excite interest and some structures are many times greater than this. The usefulness of the gravity meter in oil exploration depends on the fact that density usually increases with depth. The figures supplied for a survey are usually presented graphically on maps by lines of equal gravimetric force known

as "gravity contours." Such contours are usually regarded as representing the topography and structure of the basement beds and consequently the overlying structure, except where special geological conditions are known to exist. The most important of these special conditions is in the area of salt domes, as in the Gulf Coast of Texas and Louisiana. There the oil is trapped around salt plugs surrounded by denser material, consequently the gravity picture compelling the interest of the prospector is one of comparative gravity minima rather than one of maxima figures.

Due to the activities of newspaper and magazine articles devoted to the popularization of science nearly every one is familiar with the principle of sonic sounding now used on ship board. In this a sound wave, usually of audible frequency, is transmitted from one part of a ship's hull and reflected back to another from the ocean bottom. Since the speed of sound in water is known the depth to the bottom may be readily calculated. No such ideal result is possible in subterranean soundings but the principle is utilized in seismic surveys for oil exploration. The instrument used is a seismograph, an instrument used to detect and record earthquakes. In geophysical exploration the portable type records earth disturbances caused by the explosion of dynamite at or near the surface. There are difficulties in subterranean sounding not found in submarine work since the various beds in the earth's surface have velocities varying in depth and horizontal distance. The dynamite shots creating the earth disturbance are picked up in the detectors, usually five to ten or more, located in line with the recording truck at distances of from 100 to 300 feet apart and about 1000 feet from the shot hole. The average depth of a shot hole is between 50 and 75 feet and the size of the charge around 10 pounds. However they may be as small as the detonating cap only or many times greater. Twelve or fifteen men using at least seven cars of trucks make up a typical reflection seismograph crew. The data available in a seismic survey are the distances between the shot-point and detectors, the mean velocity of sound through the earth strata overlying the reflecting bed and the information fro mthe seismograms, that is, travel time between the detonation and recording points by way of the reflecting horizon. For use by the operator these quantities are converted into depths to the horizons mapped and a contour map is prepared, frequently supported by cross sections. This map is harmonized as far as possible with the known geological factors present and location for a test well is made. The reflection seismograph is most in favor with oil operators at present. It has been termed the "most definitive" of geophysical methods used in oil exploration.

The seismograph has also been used in the refraction method, wherein the seismic wave is refracted as it passes from the overlying

shales and sands to a high-speed layer of hard rock strata below and its travel time determined by detectors set several miles away. This method was introduced in 1923 and was very satisfactory in locating salt domes in the Gulf Coast and other structures of high relief, but since most oil field structures have a relief of less than 100 feet, the refraction method soon served its purpose and was superseded by reflection mapping. Another great disadvantage lies in its greater cost, usually due to greater shot demands, but somewhat of an offset is the advantage that a single shot maps a greater territory making it possible to map areas otherwise inaccessible.

In addition to these geophysical methods used there are many electrical methods employed. Though they have been successful in Roumania and Russia, American geophysicists have not given them much place in petroleum exploration, due to the feeling that their efficiency and cost do not compare favorably with those of seismic and

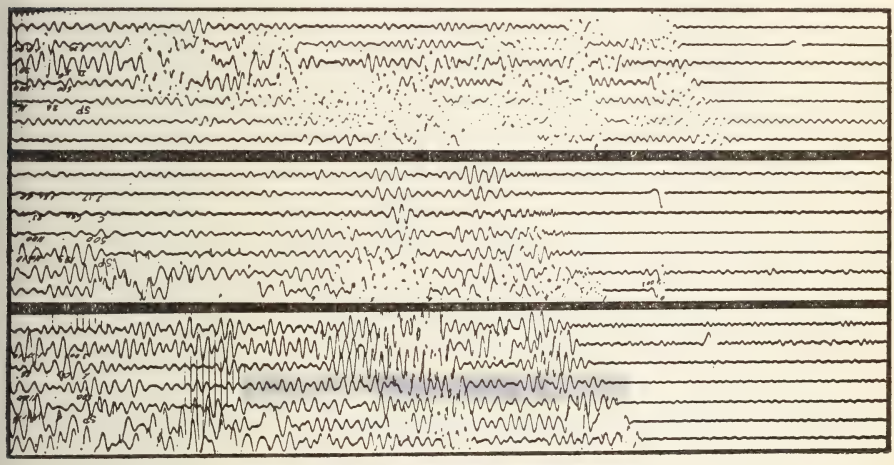

Fig. 3.—Specimen Electric Log.

gravity methods. Though electrical methods have their enthusiastic proponents it is safe to say that these methods are viewed askance by most American authorities so they will be only briefly mentioned here. The method consists in studying the electrical or magnetic fields produced by an energizing circuit, either direct, alternating, or one of the many types of transient currents made to flow directly into the ground by electrodes or inductively with an ungrounded loop. The voltage produced between electrodes is measured and the result is a purely qualitative picture of the electric anomalies or computations of resistivity give figures that may be translated into depth figures on which a contour map may be drawn.

Approximate costs of the different methods run as follows: magnetometer, $1,000 - $1,500 per month; gravimeter survey, $4,000 per month; reflection seismograph, about $10,000 per month. Electrical

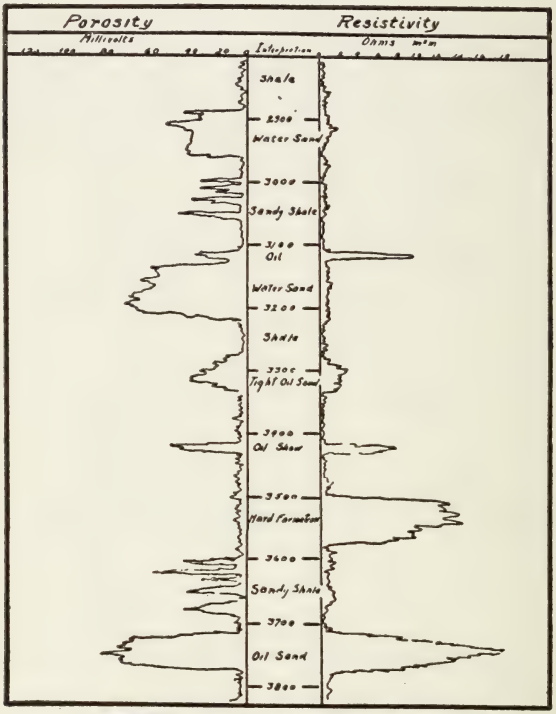

Fig. 2.—Specimen Seismograph Record.

methods cost about the same as the reflection seismograph and the refraction crew costs several times that per month. Of course it will be recognized that figures may depart widely from these estimates due to local conditions at the time of survey.

In subsurface work with geophysical instruments the outstanding development is the use of an electric logging device. The two most commonly used in the Gulf Coast are the Schlumberger apparatus and the Halliburton "Jeep." In this method three electrodes are lowered into the well and through one an electric current is introduced into the geologic formation. This creates a difference in potential from which the resistivity may be computed. Through one of the electrodes connected with a potentiometer at the surface, the natural potential may be computed. This is interpreted as indicating the porosity of the formation. In practice these effects are recorded auto-

matically at the surface furnishing a log strip as in Fig. 3. In these logs the porosity is compared with the resistivity at equal depths and when an increase in one coincides with an increase in the other it is presumed that oil is present at that depth. This procedure has caught the imagination of the public and frequently gives rise to unjustified optimism, but the industry has found that there are electrochemical characters other than oil in the formations or water that will give a seemingly favorable record. As a consequence, though there are conspicuous discoveries of oil by the electric log where the oil was not indicated by any other means, geologists today use these logs as a supplement to or a substitute for lithologic logs. The usefulness of the electric log is limited by the fact that it will not register in cased portions of a well. To meet this difficulty a later device has appeared in the oil fields, a well logging apparatus indicating the radio activity of formations, frequently known as the "gamma ray". Since the radiations can penetrate many inches of iron a survey may be made of cased holes.

Many other surveys of bore holes are made, for temperature, pressure deviation, etc. Not only are the characters observable in a bore hole of value to the geologist in his correlation of wells but furnish data to the petroleum engineer for the efficient completion and operation of the well.

GEOCHEMICAL METHODS

The latest development in petroleum exploration is "geochemistry" or "soil-gas analysis". Its thesis is that the geologic column above an accumulation of oil differs in its chemical properties from those of adjacent sediments. Since the so-called impervious formations above oil fields are not absolutely so it is postulated that small amounts of gases escape from an oil pool and ascend to the surface of the earth and indicate the location of the pool. The presence of these gases is determined by the chemical analysis of the soils near the surface but as yet no satisfactory explanation of the mechanism involved in this migration has been advanced. The last annual meeting of the American Association of Petroleum Geologists devoted much of its time to the presentation and criticism of this method. The proponents of geochemical prospecting revealed many significant data, the critics attacking the method because, as they contended, explanations were inadequate for the formulation of an embracing theory. Though only two discoveries by this method are claimed by its supporters, the significance of these, as was there pointed out, surpassed the commercial importance of any production established in them. The prospects are that geochemical exploration will play an important part in the search for oil reserves in the future.

The chemists are active in other ways in the drilling and completion of wells. The cuttings are examined chemically for their hydrocarbon content to indicate the presence of oil or gas, and also to be used in correlation with nearby wells. Also, mud has to be controlled for viscosity and weight by conditioning with various chemicals, bentonite, sodium silicate, sodium carbonate, solidified naphthalene and silcon tetrachloride, to name only a few. In addition wells producing from calcareous horizons are regularly completed by the introduction of acid to the producing horizon to dissolve the lime and permit freer entry of the oil into the well. Sometimes the acid used amounts to as much as 15,000 gallons per well.

MAPS AND CROSS-SECTIONS

Data obtained by the above means are presented to the oil industry in the form of maps, cross sections, models, block diagrams, etc., but more frequently as maps and cross sections. These maps may be grouped in three classes: surface, subsurface and geophysical (and geochemical). Surface maps may be topographic or aerial photographic maps, maps showing structure by contours or simply by dip and strike symbols, or maps showing the geological formations exposed or inferred to be present. Subsurface maps may be drawn to show the geology exposed at any particular time. Such maps are termed "subareal maps'," "paleogelogic maps" or simply "pre-" any given horizon. Subsurface contour maps showing structure are drawn on datum points found by simply subtracting the elevation at the surface from the depth to the key horizon. Contour maps are also drawn to show the thicknesses of various formations and are known as "isopach" or "convergence" maps. When such maps are drawn on the producing horizon they may be known as "sand maps" or "sand thickness maps."

Geophysical data are usually represented by contour maps drawn either on the quantity of the character mapped as in magnetic or gravity surveys, or upon a depth deduced from some physical character as in seismic or some electrical surveys. Miscellaneous maps are made for the purpose of graphic presentation, with any character that can be reduced to quantitive values serving as a basis for contouring such as gasoline content, carbon ratio, salinity of the oil field waters, etc.

Conditions existing in oil fields or inferred to exist in prospects are frequently depicted in cross sections normal to the plane of the map. As in the case of maps they are drawn to illustrate one or several features of the subsurface.

Most of the material in this paper is drawn from the experience of the writer. When necessary to refer to the literature the publications of the American Association of Petroleum Geologists, the American Institute of Mining and Metallurgical Engineers, and the American Petroleum Institute have been consulted.

THE FUNCTION OF A SUPREME COURT IN AMERICAN CONSTITUTIONAL GOVERNMENT

James Miller Leake
University of Florida

In 1783 Great Britain by the Treaty of Paris recognized thirteen of her former American colonies as independent states. These colonies by July, 1776, had banded themselves together; had adopted a declaration announcing themselves to the world as free, sovereign and independent states; and each had made provision for carrying on its own government. To prosecute the war by which they hoped to win their freedom from British control, they had taken steps to organize a loosely-linked union under the Articles of Confederation.

Long before the successful conclusion of the seven years' struggle, the weaknesses of this Confederation government had become amply apparent. Without any real executive; with only the most rudimentary judicial machinery and no common citizenship; without any power of taxation and dependent upon requisitions on the individual states which Congress was without power to enforce; with a unicameral legislature, often weak and vacillating and sometimes supinely impotent, those who suffered most from the Continental Congress's lack of effectiveness realized most keenly the need for a stronger and more efficient general government.

Noteworthy among these were General Washington and two young men who had been closely associated with him since the dark days at Valley Forge, Alexander Hamilton of New York and John Marshall of Virginia. All three would be leaders in the fight for a better government, under a stronger constitution. In its formulation and adoption each would play an important part. In the interpretation of that constitution Marshall's influence would be definitive.

The need for a stronger and more effective general government, so apparent in 1783, became more and more evident during the following early years of peace. These years John Fiske has well-named the "Critical Period of American History."

How could a government without the power of raising sufficient revenue to meet its current operating expenses and annually defaulting on its domestic and foreign debt, long endure? How could the concerns of the general government be looked after by a Congress with only the mere semblance of any real power or authority?

This ever-increasing realization of the inadequacy of the Articles of Confederation, together with a growing recognition of the make-

shift character of the general government under them, led inevitably to the Federal Constitutional Convention of 1787 and to the drafting and ratification of our Federal Constitution.

The members of this Convention, although they had specific instructions only to amend the Articles, very wisely exceeded their instructions and, discarding the all-but-worthless Articles, devoted their time and energies to the framing of a real Constitution with provisions for a workable and practical governmental system. Unlike the French National Assembly, which two years later would begin work on a French Constitution, based largely on abstract *theory,* a constitution which was destined barely to outlive its making, our "Founding Fathers", although many of them were well-versed in political and governmental theory, drafted our constitution on the intensely *practical* basis of compromise and adjustment, and on the lessons learned in the hard school of colonial and state governmental experience.

Their approach was far more *realistic* than *theoretical* and the constitution which they drafted during their labors in Philadelphia, with the changes of twenty-one amendments, still remains the basis of our governmental system and the guardian of our liberties. For more than 153 years it has stood, the living and working proof that a large measure of self-government and personal liberty under law is possible; and that largely autonomous states, with wide economic, geographical and social differences, can federate under a representative republic.

These delegates were confronted with some very baffling problems. They had to hammer out conflicting views on the anvil of debate and iron out conflicting interests by conciliation and counsel. Turning from the weak Confederation, which some still vainly hoped might be amended into a workable form of government, they had the wisdom to stop far short of the centralized national system which Hamilton desired and planned. Compromising between the *Randolph* or *Large State* plan, which had been offered by the Virginia delegation, and the *Paterson* or *New Jersey* plan, which was supported by the smaller states, they formulated a federal type of government, with a definitely marked-out field of central authority and a carefully reserved sphere of state action.

No close student of the records of this Federal Constitutional Convention, and of the conventions of ratification in the several states, can fail to note that the idea of *constitutional* limitations held a dominant place in the political thought of this period. The Constitution *enumerated expressly* the powers of the Congress and, in the "necessary and proper" clause, made provision for the "implied" powers.[1] It fur-

[1]*Constitution of the United States*, Article I, Section 8.

ther laid certain *prohibitions* or limitations on the Federal government[2] and on the states.[3]

Not only did the Constitution thus define and delimit the spheres of Federal and state authority; but it marked out very definitely the powers and duties of each of the three *coordinate* branches, legislative, executive and judicial, of the general government, and provided for the basal organization of each branch.

Thus was established a system of "checks and balances" in which, so far as was possible in a workable system, Montesquieu's doctrine of the separation of governmental powers was carried into effect.

Finally, to win sufficient votes for ratification in the various state conventions, in some of which decided opposition to ratification had developed,[4] it was agreed between the opposing leaders that the first Congress under the new Constitution should submit to the states amendments constituting a bill of rights and safe-guarding specifically the reserved powers of the states. This gentlemen's agreement was scrupulously kept, with the result that in 1791, the first ten amendments became a part of the fundamental law.

With this hasty summarizing of our constitutional system and its background, let us now proceed to a brief consideration of the place of a Supreme Court in that system.

Whether the power of the Supreme Court to pass on the constitutionality of statutory enactment, even on acts of Congress, is *derived from the Constitution;* or whether it be viewed as usurpation, the other alternative point of view, is too lengthy, intricate and unfruitful a subject to be gone into fully in a paper of this length. The earlier and more generally accepted view, and the one held by the writer of this paper, is that any careful reading of Article III of the Constitution along with the *Federal Supremacy* clause of Article VI, would seem not only to justify the exercise of this power by the Court, but even to make it mandatory upon the Court as a judicial duty.[5] Whether this power is *express* or *implied* is debatable.[6] Eminent authority could be cited in support of either view.[7]

Even were all constitutional basis for the exercise of this power waived, it does not seem to the writer that a power claimed for the court from its early existence, and used without very serious question

[2]*Constitution of the United States,* Article I, Section 9.

[3]*Constitution of the United States,* Article I, Section 10.

[4]This opposition to ratification was especially strong in New York, Massachusetts, Virginia, North Carolina and Rhode Island.

[5]*Constitution of the United States,* Article III and Article VI.

[6]W. W. Willoughby, *Constitutional Law of the United States* (2d ed.; New York: Baker, Voorhis and Co., 1929), Vol. I, p. 7 and footnote.

[7]*Idem.*

since the decision in Marbury v. Madison[8] in 1803, can at this late date seriously be questioned.

As early as the ratification of the Constitution, the principle of the state courts passing on the constitutionality of statutes, was not unknown. Patrick Henry, leading spokesman of the opposition to ratification in the Virginia Convention, expressed the fear that the Federal Judiciary would not be sufficiently independent to declare acts of the Congress unconstitutional.

> Yes sir, said the famous Virginia orator, our judges opposed the acts of the legislature. . . . They had the fortitude to declare that they were the judiciary and would oppose unconstitutional acts. Are you sure your federal judiciary will act thus? Is that judiciary as well constructed and as independent as the other branches, as our state judiciary? . . . . I take it as the highest encomium on [Virginia] that the acts of the legislature, if unconstitutional, are liable to be opposed by the judiciary.[9]

Much of the criticism of those who oppose "judicial review" would seem to rest on the assumption that in no other constitutional system is such power vested in the judiciary. The answer to this criticism is obvious. Our Constitution and the governmental system it set up were not copied from any existing system. Our forbears had suffered too many evils under the British principle of parliamentary omnipotence during the pre-Revolutionary period, to trust their hard-won liberties to an unrestrained legislature. It was to safeguard these liberties that definite limitations were imposed on legislative power. If these limitations were to be effective, since the Congress and the President, through his message and veto power, participate in legislation, how could these constitutional inhibitions be applied to legislation except by an independent and fearless judiciary?

That is the legislative branch of government which Madison, himself a member of the Congress, feared and was viewed as the more likely to overstep its constitutional bounds, will be clear to anyone who reads his forty-eighth number of *The Federalist*.[10]

Nothing speaks more eloquently for the claim that the framers of the Constitution wished an independent, fearless and non-political judiciary than that provision of Article III of the Constitution, which states that:

> The judges, both of the Supreme and inferior courts, shall hold their offices during good behavior, and shall, at stated times, receive for their services, a compensation which shall not be diminished during their continuance in office.

It was the attempt by the President in his "Court-Packing" plan to violate this principle that did much to mobilize opposition to that proposed legislation. Calling it a "voluntary retirement" measure did

[8]*Marbury v. Madison.* 1 *Cranch* 137.

[9]A. J. Beveridge, *The Life of John Marshall* (Boston: Houghton Mifflin Co., 1916), Vol. I, p. 430.

[10]*The Federalist,* Number XLVIII. This number was written by Madison.

not obscure its real purpose, the removal or neutralization of those justices who would not bend to the executive will.

Without claiming that the justices of the Supreme Court have been supermen, or that they have always been completely right in all of their decisions, the writer dares to maintain that they compare very favorably with members of either the legislative or executive branches of government. Possibly, their general average might be higher. Certainly, they have been more independent and less susceptible to political influences. Save when they have allowed political, economic and social questions or considerations to influence their decisions on constitutional matters, properly decided on the basis of constitutional power, when one considers the vast number of intricate and complex cases in which they have had to pass judgment, their interpretations of the Constitution have, in the long run, been remarkably consistent. Strange to say, those who have been most severe in their criticism of decisions in which they claim the justices have been influenced by economic, social or political factors, would probably have been most lavish in their praise had the court's consideration of such factors carried it the other way. The same persons who pilloried Taney for his majority opinion in the *Dred Scott* case, loudly acclaimed Curtis whose dissenting opinion was certainly quite as political in some of its implications. Neither praise of the one nor blame of the other settled the questions at issue. The final answer, and the proper one to decide such political questions finally, was the adoption of the thirteenth and fourteenth amendments.

If our theory of constitutional limitations on legislative power is not to prove a fantastic dream; if it is to remain the most distinctive American contribution in the field of government,[11] then we must return to the idea, so far as it is humanly possible to do so, of looking to independent and non-political courts to test the constitutionality of law.

Since February 5, 1937, many of the time-honored landmarks of American constitutional interpretation have been profoundly altered, if not temporarily entirely abandoned.[12] Changes, far more sweeping than some of those brought about in the past by the adoption of Constitutional Amendments, have recently come through executive pressure and Presidential attack on the courts. Well-established judicial precedents and traditions have been brushed aside entirely, or have been modified beyond recognition. The theory of a Supreme Court to go with the President, threatens to replace the long-held ideal of a Supreme Court to go with the Constitution.

[11]Willoughby, *op. cit.*, Vol. I, p. 2.

[12]H. Arthur Steiner, *Significant Supreme Court Decisions, 1934-1937,* (New York: John Wiley & Sons, 1937), pp. 1-3.

On May 27, 1935, nine Supreme Court justices, conservatives and liberals alike, concurred in the decision in the case of the *Schechter Corporation v. United States.*[13] In this decision the Court declared unconstitutional certain parts of the *National Industrial Recovery Act.* The unanimous opinion of the Court was read by Mr. Chief Justice Hughes. Its interpretation of the commerce clause, its ruling on the delegation of legislative power, its differentiation between inter- and intra-state commerce, its refusal to pass upon the economic soundness of the "chicken-killing" code, caused no surprise to those conversant with the precedents and with court decisions on similar legal questions. Up to 1937 any close student of Constitutional Law might have safely predicted the decision and the legal reasoning upon which it was based. Even the unanimity of the Court was of little surprise.

Almost a year later came the decision in *Carter v. Carter Coal Company et Al.,*[14] handed down by the Supreme Court on May 18, 1936, with six justices concurring in the majority opinion read by Mr. Justice Sutherland. In this decision the *Bituminous Coal Conservation Act,* an unusually carelessly drafted piece of legislation, was held unconstitutional. Not only was the general welfare clause as a source of congressional power distinctly rejected; but the decision pointed out the fact that it had always, when previously urged on the Court, been "definitely rejected." This decision, too, followed closely well-established precedents.

In dealing with the labor provisions of this Act, the decision declares:

> The Government's contentions in defense of the labor provisions are really disposed of adversely by our decision in the *Schechter* case. The only perceptible difference between that case and this is that in the *Schechter* case the federal power was asserted with respect to commodities which had come to rest after their interstate transportation; while here, the case deals with commodities at rest before interstate commerce has begun. That difference is without significance. The federal regulatory power ceases when interstate commercial intercourse ends; and correlatively, the power does not attach until interstate commercial intercourse begins. There is no basis in law or reason for applying different rules to the two situations. . . . . .

It is only necessary to point out that the position taken by the Supreme Court in these cases can be supported by ample precedents, early established and followed with remarkable consistency throughout our Constitutional history. Since the threat of "court-packing" the position taken by the Court in these cases has been materially changed. In such cases as *National Labor Relations Board v. Jones & Laughlin,*[15] upholding the constitutionality of the *Wagner Act,* decided on

[13]*A. L. A. Schechter Poultry Corporation et Al. v. United States,* 295 U. S. 495; 55 S. Ct. 837.

[14]*Carter v. Carter Coal Company et Al.,* 298 U. S. 238; 56 S. Ct. 855.

April 12, 1937, and in *Stewart Machine Company v. Davis*[16] and in *Helvering v. Davis*,[17] upholding the constitutionality of the Social Security Act on May 24, 1937, the Supreme Court's majority swung away from principles clearly and unequivocally enunciated in the *Schechter* and in the *Carter* decisions. In the interim between these conflicting opinions came the President's attack on the Court and the introduction of his "Court-Packing" measure.

Did the Justices who "switched" from the Court's majority in the *Carter* case to the dissenting minority of that case, thereby transforming this dissenting minority into a majority in the cases upholding the constitutionality of *Wagner* and *Social Security Acts*, make this "switch" on honest legal reasoning and sincere conviction; or were they changed by executive pressure and the fear of the threatened "Court-Packing" bill? Were they testing statutory enactment by the yard-stick of the Constitution; or were they playing a smooth game of politics to circumvent the schemes of the President and thereby save the Court? This is a question that time alone may answer, if it be ever answered; yet it is an important question, involving as it does a people's faith in the independence of our highest Court.

As one who sincerely and deeply believes in Constitutional limitations made vital through a politically independent and fearless judiciary, the writer ardently hopes that the United States Supreme Court may remain a *law-interpreting* and not a *policy-forming* body and that it will continue to test all statutes in terms of the powers granted in the Constitution. That it may long continue a coordinate branch of our government, fearlessly and impartially testing the acts of authority by that Constitution from which all legal Federal authority is derived; that it may continue to dispense equal justice within the law; and that it may continue to function as the great arbiter in the determination of governmental power under the Constitution, should be the prayer of those who value, and would pass on to posterity, our priceless heritage of representative institutions.

So to interpret the law of the land that our Federal system may operate, each branch keeping within the bounds meted out by the Constitution, this is the main function of our Supreme Court. Only by independence from executive or legislative interference can it remain a real Supreme Court and keep its rightful place in our governmental system.

[15]*National Labor Relations Board v. Jones & Laughlin Steel Corporation*, 301; U. S. 1; 57 S. Ct. 615.

[16]*Charles C. Stewart Machine Company v. Harwell G. Davis*, 301 U. S. 548; 57 S. Ct. 883.

[17]*Helvering v. George P. Davis*, 301 U. S. 619; 57 S. Ct. 904.

HEMISPHERE DEFENSE AND AMERICAN SOLIDARITY

Sigismond de R. Diettrich
University of Florida

Our country strives for peace, fair dealing among nations, and the welfare of human beings.—Franklin D. Roosevelt.[1]

I. INTRODUCTION

Since the outbreak of the present European hostilities, the cardinal foreign policy of the government of the United States has been to provide security to the free peoples of the Western Hemisphere. The ever-increasing military supremacy of the axis powers, their unveiled desires for world domination, necessitated a revaluation of our policy of neutrality. Today we feel that the forces liberated by the present conflagration are not merely European in their scope. Imbued by their military successes, the rulers of the axis powers are not only rearranging the map of Europe, but are speaking of a "new order" in that war-torn continent—a "new order" which challenges every single principle of our way of life.

Under these conditions the nations of the Western Hemisphere felt the necessity of full development of an American solidarity, a spirit of unselfish cooperation. Fully realizing the significance of the magnitude of this problem, our government did its utmost in order to establish and maintain friendly economic and political relationships between the Anglo-Saxon and Ibero-American countries. The general public, too, became aware of this problem and Pan-Americanism and Inter-American solidarity have become the most popular catch-words of our day.

II. AMERICAN SOLIDARITY

Pan-Americanism has meant, in a vague fashion, certain economic and political cooperation among the American republics. Certainly, it meant something different for the business men of the United States than for the masses of Ibero-America. Not only does the meaning of Pan-Americanism change with location, but it changes with time. Like all living ideas it undergoes great changes during its process of evolution.

[1]Samuel Guy Inman, "Introduction" quoting President Roosevelt's letter to the conference of Wharton School of the University of Pennsylvania "The Lima Conference and the Future of Pan-Americanism. March 10-11, 1940." *The Annals of the American Academy of Political and Social Science.* (later referred to as *The Annals*), Vol. 204 (July, 1939), p. 129.

Pan-Americanism today means the policy of the Western Hemisphere countries to establish American solidarity in the face of the common danger. This, however, is only a temporary interpretation. We have to think and plan not only for the immediate future. The present war, the common danger, no matter how long it is going to last, is going to be terminated sometime in the future. What then? The common danger gone, shall we depart from our common policy? Shall we shelve American solidarity? Doing that would be retrogression; thus we have to evolve a long range policy and Pan-Americanism must become the corner stone of the policy of all American countries. This Pan-Americanism then shall mean the fullest economic cooperation and political solidarity between all of the sovereign American countries for the maintenance of peace and liberty in the Western Hemisphere. Even more than this, it should mean an unquestionable guarantee of peace and liberty to the whole world.

Pan-Americanism aspires to build up a hemisphere policy of solidarity based upon our common will for peace and our belief in freedom and democracy. Common desire for cultural and political solidarity is an important factor, but unless substantiated by economic cooperation it is a fragile motive which could be shattered by the onslaught of hostile economic forces. Only through the fullest economic cooperation between the Western Hemisphere countries can we establish American solidarity permanently.

III. ECONOMIC COOPERATION

Economic cooperation, whether from the point of view of the day as hemisphere defense or from the long range point of view of American solidarity, is the firm, enduring foundation upon which the Western Hemisphere countries have to build their mansions of political and cultural life. It is useless to talk about hemisphere affairs if some hostile outsider could force any one of the Western Hemisphere countries to its knees by an economic "blitzkrieg." This is too apparent to need any further explanation.

From an economic point of view, there are several aspects of American cooperation. First there is the immediate problem of hemisphere defense. There the main questions are: (1) how much of the essential food stuffs, raw materials, and manufactured goods is produced within the geographic area of the Western Hemisphere? (2) to what extent could American resources replace the raw materials which have been secured from non-hemisphere regions? (3) what actions shall be taken in view of these considerations? Let this be called the short range economic program.

There is, however, another set of problems—the question of the future of the Americas. We are increasingly living closer together today than yesterday, and tomorrow than today. Under such conditions it would be a great mistake not to look beyond the troubled horizons of today and not to try to see the future. If we are satisfied with American solidarity as a temporary measure only, then, let us plan for today; but if we desire to formulate a new guiding principle not only for our selfish selves but for all of the desperately hoping humanity, we must lay solid foundations, and we have to think in terms of long range plans, in which we see not only America, but the rest of the world as well.

The third problem complex deals with the economic relations between the western hemisphere and the rest of the world, especially Europe. In these problems we cannot neglect and overlook the rest of the world; we are bound to reckon with the rest of humanity.

To understand fully the ramifications of these complicated problems we have to examine the economic resources and life of Ibero-America. The vast southern area of the western hemisphere is predominantly a food and raw material producing region of the world. Although it is rather sparsely populated, yet it is a productive region; thus Ibero-Americans can export large quantities of food stuffs and raw materials. Caribbean and Central America account for more than ¾ of the total banana exports of the world. Argentina alone supplies over ⅔ of the beef and veal exports of the world; including the other producing areas Ibero-America produces ¾ of the same. Similarly, Brazil dominates the world's coffee market, Argentina the corn and flax seed exports of the world, and Chile the natural nitrate exports. Almost half of the world's sugar and hides exports originate in Ibero-America. In cacao, copper, and petroleum the southern republics account for about ⅓ of the total world exports, and a smaller proportion of cotton, tin, wheat, and wool. Besides these chief articles of international trade, Ibero-America provides important quantities of minerals, forest products, and fruits.

The wide variety of resources and products denotes a great variety of environment. For our purposes we can divide Ibero-America into two sections. One comprises the lands near the equator, mostly hot humid lowlands or pleasant but isolated highlands and plateaus. The other section (by far the more important but much the smaller) is the subtropical and temperate lands of southern South America, predominately lowlands. The three leading republics, Argentina, Brazil (the part that counts), and Chile are located in this latter region. The other republics occupy the tropical lands.

The United States itself being a temperate country, most of Ibero-America forms a complementary geographic area; thus the trade relations should be active between the two regions. Southern South America presents a different picture. In stages of economic development, the United States and temperate South America would appear to be complementary, because the first is predominately manufacturing and industrial, the second a raw material and food producer. But the geographic affinity between the two areas counteracts the economic factor. The United States itself is still an important producer and to a certain extent an exporter of the very same crops that constitute the economic backbone, especially, of Argentina[1] to wit, corn, wheat, beef, cotton, and pork. These conditions greatly handicap our economic relations and form the weakest link of our political solidarity.

From the economic point of view the main South and Central American products can be classified (in relation to United States economy) in three major groups: (1) non-competitive complementary products like antimony, balata, bananas, cacao, carnauba wax, castor beans, chicle, coffee, diamonds, divi-divi, flax seed, manganese, platinum, quebracho, quinine, rubber, tin, toquilla fibre; (2) semi-competitive products—for instance, hides and skins, iron ore, long staple cotton, nitrates, sugar and wool; (3) competitive products such as beef, citrus fruit, copper, corn, petroleum, pork, short staple cotton, vegetable oils, and wheat.

The geographic conditions which govern the various types of production are responsible for the actual distribution of the diverse producing areas. After close scrutiny it becomes apparent that the Central American, Caribbean West Coast and Tropical South American regions produce, with the exception of flax seed, all the complementary and most of the semi-competitive products, whereas the non-mineral competitive products are raised in the southern part of South America in Argentina, Chile, and Brazil (cotton). Naturally, mineral production does not follow climatic variations; thus petroleum and copper appear in many complementary regions.

The closely knit economic organization of the extracting industries, the overwhelming dominance of the United States' capital in the copper, and its strong position in the petroleum industry reduces much of the actual competitive character of these two. Furthermore, we are not only chief producers, but also chief consumers of these products. As long as the United States is going to maintain its supremacy in the manufacture of copper and refining of petroleum, there will be little direct competition between Ibero-America and United States production of these two minerals.

As a result of this distribution of chief export commodities, inter-American trade relationships follow a concordant pattern. In the complementary areas the United States dominates the foreign trade of the republics. This dominance is the strongest in Central and Caribbean America.

The second group consists of the mountainous west coast republics of Ecuador, Peru, and Chile. In these countries our trade position is strong but not dominant. In these countries we take approximately ¼ of their exports and supply their imports in the same proportions.

The east coast republics form the last group of countries consisting of Brazil, Paraguay, Uruguay, and Argentina. The United States is firmly entrenched in Brazil. We are the greatest consumers of coffee; we prefer the Brazilian strong coffee to the other mild varieties. Thus we take a higher percentage of their exports than the three next best customers combined. Similarly we supply them with 23% of their imports.

Paraguay is a small republic. Hemmed in on all sides by other countries most of her trade is with Argentina. Only during the last few years has there been a definite tendency to trade directly with other countries instead of trading through Argentina. With Paraguay our direct trade is negligible. In 1937 we supplied and purchased slightly over 7% of her imports and exports, cash value about $650,000.

Uruguay is another small country, but considerably more significant than Paraguay. Her imports are four times and exports five times as great as those of Paraguay. The per capita trade of Uruguay is among the highest in Ibero-America. The republic is predominantly a stock raising country; only 10% of the exports are not animal products. Hides and skins constitute slightly more than half of the total exports. We take about 15% of the exports and supply 13% of the imports of Uruguay.

The great republic of Argentina presents the most difficult problem in South America. It is the second largest country, with an almost pure white population located mostly in the temperate lowlands of the continent. The similarity of production makes the United States and Argentina competitors in domestic and world markets. As a result, our trade with Argentina is small in comparison to that of Great Britain or even that of Germany. We have taken slightly over 16% of the Argentine exports and supplied 14% of their imports. Expressed in percentages these figures are low indeed. However, if we look at absolute figures we get a different picture. In 1937 our exports to Argentina amounted to $76,800,000, representing 16.4% of the total Argentine imports. This equalled the value of all the

Cuban imports and has exceeded the total import values of all but three Ibero-American countries. Similar was the situation with Argentine exports to us. They amounted to $96,600,000 or 12.8% of the total exports. Only five countries showed higher values of their total exports, while one equalled it, and the rest of the republics did not reach anywhere near this figure. This clearly illustrates the great economic significance of Argentina. In 1938 Argentine exports represented 24% of all the Ibero-American exports, and her imports accounted for almost 30% of all Ibero-American imports![2]

We have reviewed our position in the foreign trade of Ibero-America. Except for Argentina and Uruguay there is no cause to worry; we are strongly entrenched in the Ibero-American external trade relations. Yet, especially in recent years, there have developed a number of challenges to our predominant position in relation to the southern republics. New methods of approach have been devised, new theories advanced to bring about a redistribution of the Ibero-American trade. Let us briefly examine these theories and practices in the light of the present economic and political conditions.

IV. OBSTACLES OF INTER-AMERICAN TRADE

Since the great depression of 1929, the seemingly solid foundations of our economic life suffered a great number of shocks which played havoc with many of our "orthodox" economic ideas and institutions. In the cataclysmic collapse of our economy, agriculture and mineral production suffered the worst price depreciations. These conditions affected profoundly the trade relations of Ibero-America. The southern republics produced a large share of the world's food and raw material export commodities—goods which suffered most due to the depressions. The value of Argentina's exports, which amounted to $1,016,936,000 in 1928, has shrunk to $282,100,000 in 1932, showing a decrease of 74.2%. If this decrease had been accompanied by a similar decrease in the volume of exports, conditions would have been serious, but not tragic. As it has happened, the quantum of exports was reduced by only 10%. The peak of Argentina's imports came in 1929 with $819,509,000; the bottom was reached in 1933 with $222,300,000. This represented a 73.1% decrease in value, whereas, the decrease in quantum during the same period amounted to 49.3%. Thus, while the reduction in values was approximately the same, in quantum there was a difference of 39.3%, clearly indicating a reduction of Argentina's purchasing power by over ⅓ of its

[2] *The Foreign Trade of Latin America, Part II, Section I. Argentina* (United States Tariff Commission, Washington, D. C., 1940), p. 12.

value of 1929. This example, with certain modifications due to local conditions, could be repeated for each one of the Ibero-American republics. As a matter of fact, it is true not only in Ibero-America and in our internal economy, but all the world over. The collapse of the purchasing power of the world's primary producers is one of the cardinal defects of our economic world.

What is the character of our trade with Ibero-America? Our import trade does not involve great difficulties. We import mainly raw materials and tropical foodstuffs. The amount of our imports does not vary greatly with the price, since most of our demands are more or less inelastic, as in the case of coffee, bananas, and other foodstuffs. The importation of industrial raw materials varies more in volume than is the case with foodstuffs, as the former depend more on industrial production and not so much on prices. Falling prices certainly did not increase anywhere the consumption of the major export commodities of Ibero-America. Another important point is that the amount of mineral production, either through voluntary action of the mining companies or by the force of international combines, like the tin cartel, has been kept more synchronized to consumption than has the volume of agricultural production. Yet action usually was taken after the damage had been done, and the reduction of mineral production was more a means of reducing already accumulated stocks than a preventive move to avoid such accumulations.

Facing this steady demand of foodstuffs and decreasing demand for minerals, stood our export trade. Chief items of our exports to Ibero-America were automobiles, parts and accessories, gasoline and oil, rubber products (especially tires), mining machinery, agricultural machinery, iron and other metal products, electrical equipment, typewriters, calculating machines, pharmaceutical products, chemicals, paints and varnishes, temperate food products (mostly to the Caribbean countries), textile manufactures (especially cotton yarn and goods), and other high quality consumption goods. We can safely assert that all these were the best that we could offer. They were high quality and rather high priced commodities.

Great Britain supplies, usually, the bulk of staple products, such as cotton and woolen goods, coal, railway equipment, other iron and steel products, and machinery. Germany was strong in iron and steel products, kitchen utensils, cutlery, cheap tools and hardware, machinery, airplanes, railroad equipment, chemicals and pharmaceuticals, optical goods and photographic equipment, scientific instruments, and some textiles. Belgium sold most of the fine glassware, pottery, iron and steel and tin products, rolling stock, arms, laces and fine textiles. France dominated in styles, perfumes and cosmetics, high grade textiles

(especially silk and rayon goods), and pig iron. Italy mostly furnished textiles, cotton, silk and rayon, pottery, olive oil, and other Mediterranean products. Japan invaded the cotton and later the rayon market with both yarn and piece goods; however, most of the Japanese textiles are low grade, cheap products. Besides these the Island Kingdom sold large quantities of "five and ten" articles. All competitors, except Japan, sold some automobiles, but our dominance was never seriously threatened by them. The only serious competitor in agricultural machinery was Canada. European agriculture is not highly mechanized, and thus the European farm machinery production cannot successfully compete with the North American agricultural implements. (Table I)

TABLE 1*

PRINCIPAL UNITED STATES EXPORTS TO LATIN AMERICA IN 1938†
(in millions of dollars)

Commodity	Dollar value‡	Percent taken by L. A.	Percent of total exports to L. A.
Automobiles, parts and accessories	67.6	25.0	13.8
Industrial machinery	53.1	19.7	10.8
Petroleum and products	33.3	8.6	6.8
Electrical machinery and apparatus	31.4	30.7	6.4
Chemicals and related products	28.8	22.3	5.9
Steel mill manufacturers	24.1	46.0	4.9
Agricultural machinery and implements	21.9	29.0	4.5
Cotton manufactures	17.1	37.7	3.5
Iron and steel semi-manufactures	16.0	12.1	3.3
Advanced manufactures	14.8	34.2	3.0
Aircraft and parts	12.0	17.6	2.5
Lumber and wood manufactures	11.5	20.6	2.3
Wheat flour	10.0	43.1	2.0
Rubber and manufactures	8.4	30.9	1.7
Paper and manufactures	7.5	28.9	1.5
Lard	5.9	32.3	1.2
Office appliances	5.9	20.4	1.2
Rayon manufactures	4.0	36.4	0.8
All other	116.4	.....	23.9
Total	489.7	16.0	100.0

*Howard J. Trueblood, "War and the United States — Latin Amercian Trade," *Foreign Policy Reports*, Vol. 15 (Dec. 1, 1939), p. 223.

†Based on Department of Commerce data.

‡In millions.

During the depression our Ibero-American trade suffered more than our competitors. We sold luxury goods. It is hard for us to real-

ize that most of the commodities we consider as essentials are looked upon as luxuries outside of North America. Automobiles are essential in the United States. In Ibero-America, with few exceptions, there are no roads. The roughness of the Andean lands, the wet equatorial climate of Amazonia and the low density of population over most of Central and South America would make road building and maintenance very expensive. Thus only Argentina, Uruguay, southeastern Brazil, parts of Mexico, and the Central Valley of Chile have what we could call highway nets passable at all times for automobiles. The total road mileage of Ibero-America barely surpasses the half million mark, almost ⅔ of which is in Argentina and Uruguay. The little islands of Japan have 20% more roads than all the Ibero-Americas. Under these conditions cars are luxuries, and it is not essential to buy a new model while the old one is still running. It was only natural that car sales and automobile exports declined rapidly, and with that our share of Ibero-American imports contracted.

We have to begin to realize that other people have different standards of evaluation than we have. If our exporters cannot realize this difference it will only do harm. Intensive research and study and an effective dispersion of the results among the exporters and general public would certainly pay big dividends in trade returns as well as in good will and solidarity.

Similar is the situation with respect to a number of other important export articles, such as electrical appliances, adding machines, typewriters, and other office equipment. These, too, are luxury goods. When business contracts, could one expect a trade expansion in these commodities? When agricultural prices collapse, which farmers can buy farm machinery? When people are getting poorer from day to day, who will buy expensive consumption goods, even if they are of first class quality? During depressions the price demand becomes more decisive than quality. It is the cheap, low quality goods that will gain in the volume of sales, barter or no barter. The high quality of our goods and the resultant high prices, coupled with our determination to maintain the gold standard which put us in the adverse exchange position, were the real causes of our shrunken trade with the southern republics.

Another important contributing factor to our trade losses was the increased industrialization of the most progressive countries. This industrialization increased rapidly during the depression. A few figures may well illustrate this movement. In 1930 there were five spinning mills in Argentina employing 4000 laborers, in 1937 the number of textile mills and allied establishments rose to 4,727 employing 77,683 workers. The total number of manufacturing estab-

lishments was 40,613 employing 472,152 laborers.[8] These figures, as significant as they are, do not show a rapid increase in large scale manufacturing; the average number of laborers being less than 12 per factory. Nevertheless, the increase in absolute numbers is significant as an indicator of this new trend toward industrialization. Similar is the situation in Brazil, Chile, and Mexico.

Now, under the strain of war economy in the northern hemisphere, South America is going to be forced to produce an even larger share of her manufactured commodities than during the depression. We may, therefore, expect a further rapid decrease in the industrial growth of the chief Ibero-American republics. This development may mean the loss of markets of certain types. On the other hand it means the necessity of importing capital for the purchase of capital goods and for the running of the industry. That means profits to us, markets for machinery, higher purchasing power to the newly industrialized nation, and ultimately, better conditions all around. Furthermore, unless we would assume super-dictatorial powers, this process could not be stopped any more than a tree could be kept from growing. Thus, temporary losses of markets should not obscure our understandings of basic principles; on the contrary let us extend financial and moral help to our southern neighbors in their struggle of coming of age.

The third obstacle standing in the way of the full realization of our economic and political aims as well, is our great lack of understanding and appreciation of the Ibero-American way of living. Their standards may be strange and unfamiliar to us, but they *are* theirs and we have to accept this fact on its face value. We cannot remake them to our liking—at least not within a short decade or two. Thus we have to learn to know them, and to understand their way of life and why they live as they do.

The next problem in the discussion of obstacles to trade is the problem of trade rivalries. If we were the only nation trading with Ibero-America much of the problem facing us would become insignificant. We, however, are only one of the many nations who share the trade of the southern republics. (Table 2).

[8]Frank E. Williams, "Economics Diversification in Latin America," *The Annals,* Vol. 211 (September, 1940), pp. 151-152.

TABLE 2*

IBERO-AMERICAN TRADE IN 1938

AREAS	EXPORTS In millions of U. S. Dollars	%	IMPORTS In millions of U. S. Dollars	%
Total	1,834	100	1,488	100
Europe (excl. U.S.S.R.)	997	54.4	650	43.6
Great Britain	*308*	*16.8*	*174*	*11.7*
Germany	*193*	*10.5*	*241*	*16.2*
North America	573	31.2	520	35.0
United States	*554*	*30.2*	*504*	*33.9*
Ibero-American	109	5.9	148	10.0
Asia	26	1.4	71	4.8
Others	126	7.1	99	6.6

*After U. S. Ttariff Commission, *The Foreign Trade of Latin America, Part I.* (Washington, 1940), and U. S. T. Commission, *Graphic Analysis of Latin America* (Washington, 1940).

It can readily be seen that, as a whole, our economic position in Ibero-America is strong, and it has been since 1914. Yet just before the outbreak of the present war in Europe there was a great deal of nervousness about our losing our predominance, especially in southern South America. No one can deny that there were certain changes and shifts in the trade position of the important commercial nations of the world. Expressed in percentage increases, some countries showed staggering gains in their trade relations; but, reduced to terms of values these lost much of their significance.

The years of 1935-37 marked the greatest expansion of German trade during the last decade. Comparing on percentage basis Germany's share of the big four's Ibero-American import trade increased from 14.8% in 1929 to 23.6% in 1936; whereas during the same period our share decreased from 60.3% to 49.6%. Thus, against 8.8% German increase in the share of the Ibero-American trade, we registered a loss of 10.9%.[8] The matter, however, is not quite this simple. 1929 marked the top of prosperity, our luxury goods found ready markets in Central and South America. Our investments had just reached an unprecedented peak. These conditions made 1928 and 1929 exceptionally favorable to us. When the collapse came, our trade suffered more than Germany's or Great Britain's. As a matter of fact, during the first part of the depression, the United Kingdom forged ahead of us and increased her percentage share, whereas Germany held her position with a slight increase by 1933.

[4]Howard J. Trueblood, "Trade Rivalries in Latin America," *Foreign Policy Report,* Vol. 13 (Sept. 15, 1937), p. 156.

During the rapid expansion of German trade the United States increased her share also. Germany expanded more at the expense of the British than at ours.

TABLE 3*

PERCENTAGE DISTRIBUTION OF THE BIG FOUR'S IBERO-AMERICAN IMPORT TRADE

COUNTRY	1929	1933	1936	1938
United States	60.3	48.0	49.6	51.5
United Kingdom	24.0	32.2	23.1	17.8
Germany	14.8	17.5	23.6	24.6
Japan	0.9	2.3	3.7	6.1
	100.0	100.0	100.0	100.0
Big four's share of the total imports.	59.5	51.1	59.1	65.7
Value of total Imports millions of U. S. $	2,425	638.7	1,380	1,488

*Trueblood, *op. cit.*, p. 157.
Lew B. Clark, "Competing for Latin American Markets," *The Annals*, Vol. 211 (Sept., 1940), p. 167.
U. S. Tariff Commission, *op. cit.*, p. 3.
League of Nations, *Statistical Yearbook of the League of Nations* 1938-39 (Geneva, 1939), pp. 209-214.

The reason for this fact is twofold. First, the types of export commodities with which Germany supplies Ibero-America are more in the line of British than United States goods. Second, Germany's commercial relations are most closely linked with her geographic and economic complementary countries, i. e. Argentina, Brazil, Chile, and Uruguay, which in 1930 took 72.1% of the German exports to Ibero-America. In 1938, by an interesting coincidence, the value in dollars of German exports.[10] The same four republics took 80% of the Ibero- at the later date it represented only 63.4%, showing a diversification of German exports.[10] The same four republics took 80% fo the Ibero-American exports of Great Britain in 1930. 83% of the $159,000,000 decline of British exports to Ibero-America from 1930 to 1938 was caused by the decline of the imports of the four republics from the United Kingdom. This British loss was caused partly by the increased sales of Germany, United States, Japan and Italy, and partly by the industrialization, especially, of Argentina, Chile, and Brazil. Another rather important reason for the British decline was the purchase of two English railways by the Argentine government resulting in a reduced purchase of English-made rolling stock and equipment. Furthermore, there is a distinct tendency to use Diesel engines, which

[5]Clark, *op. cit.*, pp. 167-168.

replace the old steam locomotives and cut down the necessity of importing British coal. From 1935 to 1937 Great Britain actually lost $10,000,000 worth of trade, mainly in Venezuela and Chile. (Table 4).

TABLE 4*

GAINS AND LOSSES IN THE IBERO-AMERICAN IMPORT TRADE OF THE FIVE MAJOR COMMERCIAL POWERS BETWEEN 1935 AND 1937.
(Value in thousands of dollars)

Country	United States	Germany	Italy	Japan	United Kingdom	Total five large ones	Others	Total Increases
1. Argentina	30265	19387	11754	1885	19669	82960	62023	144983
2. Bolivia	1847	–1060		510	104	1401	3008	4409
3. Brazil	24082	32390	1796	16702	12086	87056	18702	105758
4. Chile	8762	10528	794	– 5	–2444	17635	8177	25812
5. Colombia	21588	1650	736	–3109	8056	27449	8603	36052
6. Costa Rica	1385	766	143	322	278	2894	588	3482
7. Cuba	33161	1417	–430	–1812	2216	34552	–445	34107
8. Dom. Rep.	1350	300	4	320	110	2084	–182	1902
9. Ecuador	1925	1516	79	–1321	–32	2167	102	2269
10. Guatemala	3638	3268	62	–381	341	6928	216	7144
11. Haiti	715	153	1	–810	887	944	39	983
12. Honduras	–160	665	68	502	–265	679	127	801
13. Mexico	34311	13918	16	1717	1542	51504	10377	61881
14. Nicaragua	507	2	4	–81	–116	316	232	548
15. Panama	1579	245	55	102	108	2089	749	2838
16. Paraguay	62	819	93	57	164	1195	–333	862
17. Peru	6736	5284	359	–203	212	11670	4327	15997
18. El Salvador	550	881	95	6	–112	1230	–311	919
19. Uruguay	297	2594	465	870	2994	7220	10775	17995
20. Venezuela	23011	6862	1032	1688	–7370	32223	6359	28582
Total	192611	101585	14608	16959	38428	364191	133133	497324
Percent of total gain	38.72	20.42	2.93	3.41	7.72	73.20	26.80	100.00
Percent of 5 major countries gain	52.88	27.89	4.04	4.65	10.56	100.00		

*U. S. Department of Commerce, *Foreign Commerce Yearbook 1936, 1937, 1398* (Washington, 1937, 1938, 1939).

TABLE 5*

DISTRIBUTION OF IMPORTS OF SELECTED IBERO-AMERICAN REPUBLICS BY COUNTRIES: 3 YEAR AV. %.

COUNTRY	U. S.	U. K.	Germany	France	Italy	Japan
Argentina						
1910/12	13	27	15	9	8	....
1921/23	23	23	12	6	6	....
1927/29	25	18	11	6.8	8.5	1
1932/34	13	22	11	5	8	2
1935/37	15	20	9.5	4	5	3.5
Brazil						
1910/12	14	27	17	9	4	....
1921/23	26	24	9	6	4	....
1927/29	27	20	12	5.5	3.5	....
1932/34	25	18	12	4.5	4.0	....
1935/37	23	12	23	3	2	1
Chile						
1910/12	13	32	26	6	2	....
1922/24	25	23	14	5	3	....
1927/29	31	18	14	....	....	....
1932/34	24.5	16	12	....	....	....
1935/37	27.2	14.3	24.9	2	1.7	3.1
Columbia						
1911/13	29	28	16	12	3	....
1923/24	48	22	9	5	5	....
1927/29	45	22	14	....	....	....
1932/34	42	19	16	5	2	2
1935/37	43	18	19	4	1	....
Mexico						
1910/12	....	....	....	....	....	....
1921/23	....	....	....	....	....	....
1927/29	68	6.5	9.0	5.5	1	....
1932/34	61	10	11	6	1	0.5
1935/37	63	5.5	13	4	0.4	2
Peru						
1910/12	22	31	17	7	4	....
1921/23	44	17	8	4	3	....
1927/29	38	14	10	....	....	....
1932/34	28	18.5	9	5	3	4
1935/37	33	12	18	2	2	4
Venezuela						
1910/12	31	26	16	11	3	....
1921/23	52	22	7	6	2	....
1927/29	55	12	9	7	2	....
1932/34	46	19	11	5	2	....
1935/37	48.2	15.4	12.4	4.5	1.6	2.9

*Based on Clarence F, Jones, *Commerce of South America* (Boston, 1928); U. S. Department of Commerce, *Commerce Yearbook,* Vol. 2 (Washington, 1928, 1929, 1930, 1932); and U. S. Department of Commerce, *Foreign Commerce Yearbook,* 1933, 1935, 1936, 1937, 1938 (Washington, 1934, 1936, 1937, 1983, 1939).

Investigating the percentage distribution of import trade and the actual dollar value of the increases in imports, we find that almost ¾ of the increase was caused by the five major Commercial powers. (Tables 4 and 5) Over half of this increase was due to increased sales of the United States and only 28% was caused by German trade expansion. The German increase was only by 1.45% more than exactly half of the gains by the United States. Only in six countries did Germany's gain exceed those of the United States. In these six republics her gain over us amounted to $14,284,000, mostly in Brazil and Chile. Our lead over Germany was many times this figure. Our net plus over the German gains reached $91,026,000. In considering the actual dollar values rather than the percentage of value, a truer picture of the actual situation is given and the German trade menace does not seem to have been so dangerous.

As far as Germany's relative share in the import trade of Ibero-America is concerned, there again, with the exceptions of Brazil, Colombia, and Peru, she did not reach her pre-World War position by 1939. Compared with the same date Great Britain lost very heavily, and the United States gained considerably. Japan is a newcomer who has made some headway. Italy and France both have lost considerably in their relative importance as suppliers of Ibero-America. (Table 5).

The big five (see Table 4) dominates the trade of Ibero-America. Within the group the United States is the strongest single nation. With the exception of Argentina and Uruguay, we control from ⅓ to ¾ of the imports of the republics. Our position is not quite as strong in terms of exports. In Argentina, Bolivia, the Dominican Republic, Haiti, and Venezuela our position is weak; Cuba, Colombia, and Mexico compensate us for this weakness of position. In the latter republics we dominate the export trade. In the rest of the countries our position is strong. Germany and Great Britain vie for the second position. The other two nations are weak in comparison with the first three countries discussed.

As a matter of fact the German, and to a certain extent the British, trade rivalry caused less concern to us on account of the amount of money involved than on account of the methods pursued. As a result of the burden of reparation and war debts payments, the foreign exchange position of Germany became critical. This led to the Hoover moratorium in 1931, but by that time Germany had lost most of her gold reserves. Seeking to find some new arrangements whereby she could purchase foreign goods essential to her existence, she established the amazingly complicated exchange control, quota system, barter trade and all the regulations pertaining to these. Germany, by purchasing heavily in Ibero-America, created large debts in blocked

marks which could be used only to buy German goods. In this way Ibero-America became the creditor of Germany and all that they could do was to enter into clearing agreements and take what Germany offered to sell, so as to get some of their loans paid back.

The German exporter, in lieu of the extensive restriction and bureaucratic red tape, received financial aid from the government and, through currency manipulation and long credit terms, would offer more attractive terms than could either the English or United States Firms.[13] On the other hand, these better terms are really not better.

As a matter of fact the conditions of trade are worse than those offered by the free exchange countries, because, after paying higher prices for Ibero-American products, these countries have to take what they can get at the prices they can get. Often Germany has resold some of the imported raw materials in free exchange countries, and thus she has competed in the best markets with the Ibero-American republics.

Barter trade is in direct contradiction with our trade principles and practices. It bilateralizes trade, whereas our reciprocal trade agreements liberate trade and tend to build up equal treatment and thus aid the revival of international trade. Barter trade ultimately has to lead to state trade monopoly, and to extreme regulation of movements of goods, capital, and even people. Thus, like the other manifestations of the present German system, their foreign trade practices contradict and oppose our way of doing business. In the process of competition, however, the barter trade system lost its original force after the initial successes, and by 1938-39 Germany not only slowed down her expansion, but, in a few instances lost some of her advantages. Naturally, the present war has greatly reduced the effectiveness of German competition, and, for the time being, the Reich does not count as a serious rival in South and Central America.

The British trade policy of late years is subject to some critical remarks too. The outstanding example of these is the Roca-Runciman Agreement of May, 1933, between the United Kingdom and Argentina which canalized the Argentine trade with Great Britain by blocking sterling exchange for the use in Great Britain after some "reasonable deductions" have been made for debt service of other

[6]W. T. Monan, "Our Latin American Trade Faces Financial Difficulties," *The Annals,* Vol. 211 (Sept., 1940), pp. 174-175.

Clark, *op. cit.,* pp. 167-169.

Trueblood, *op. cit.,* p. 127.

Max Winkler, "America looks Southward," *The Annals,* Vol. 204 (July, 1939), pp. 38-39.

Eugene P. Thomas, "Inter-American Trade Problems," *The Annals,* Vol. 204 (July, 1939), pp. 151-153.

nations. This agreement was renewed in 1936.[14] This, like the German barter system, had no permanent effect in giving the British a lasting advantage. In both Argentina and Chile, the British, like the Germans, lost trade from 1937 to 1938. The British position, like the German, only to a lesser degree, was weakened by the war and German sinking of shipping. Thus another of our serious competitors was restrained by the war.

In the last group of trade barriers belong the foreign exchange control schemes and tariff walls. Of this latter it should suffice to say that, since the depression, most Ibero-American countries have built up protective tariff walls for their infant industries. This development certainly marked a new epoch in Ibero-America. Before the depression, customs served as a basic tax, aimed mostly at the rich who used imported consumers' goods and at the foreign capitalists who imported capital goods. Import duties provided for anywhere from 25 to 60 percent of the total revenues of the Ibero-American countries. Their relative significance increased, since most governments had to abolish export duties levied against certain monopolistic products like nitrates, coffee, and others.

The reason for the establishment of the exchange control schemes in Ibero-America were manifold. Some of them arose from world conditions; for others, our rather short-sighted commercial policy is responsible. Our uncritical and too optimistic lending policy helped to overburden the economic life of Ibero-America. Then, in addition to lending them capital, we maintained a "favorable" balance of visible trade and competed with some of the republics in world markets.

The exchange control does not aim to maintain the value of currency at a pegged price. It is more stringent than that, it aims at regulations of the volume and flow of foreign exchange at an "official" rate. By the use of exchange control the various governments hope to ameliorate those financial difficulties which have come in the wake of the depression. Eleven Ibero-American republics have established exchange controls. These are: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Honduras, Nicaragua, Paraguay, Uruguay, and Venezuela. In addition to these, Cuba has a nominal control, and Ecuador a very mild partial control. In this last mentioned republic the only regulation pertains to the compulsory sale of export drafts which have to be and can be sold only to the Central Bank to provide the government with the necessary exchange in order to enable them to discharge external financial obligations.[15]

[7]Herbert M. Bratter, "Foreign Exchange Control in Latin America," *Foreign Policy Reports,* Vol. 14, No. 33 (Feb. 15, 1939), pp. 279-281.

[8]Bratter, *op. cit.,* pp. 274-276.

Naturally, foreign trade had to come under strict government supervision. Only if supervised by the governments can decisions be made about the feasibility and advisability of certain exports or, especially, import transactions. These considerations have led to the import and export licensing system.

To facilitate trading under these circumstances, barter trade and clearing agreements emerged on the one side, and "exchange understandings" on the other. The clearing agreements are the financial manifestation of barter trade by the aid of which trade is kept balanced and non-negotiable barter credits become negotiable within the same nation.

Exchange understandings are somewhat liberalized clearing agreements. One of the best examples of these is found in the aforementioned Roca-Runciman Agreement between Argentina and the United Kingdom. This agreement stipulated that Argentine importers should receive pound exchange proportionately to the British purchases of Argentine commodities. On the other hand, Argentina assured Great Britain that the accumulated Argentine credits, after the deduction of "reasonable sums" for financial services on non-British investments, would be used either for the purchases of British merchandise and/or for payments on British investments in Argentina. Similar agreements were made with Belgium, Netherlands and Spain. Britain also has a special clearing agreement with Colombia. Germany has concluded clearing agreements with Argentina, Brazil, Chile, Colombia, and Uruguay.

These regulations worked hardships on our trade. First, our whole foreign trade policy is the antithesis of canalization of trade and of the resultant inequality of treatment. Second, as pointed out before, a large proportion of our trade is luxury trade. Finally, our insistence upon a "favorable" balance of visible trade and our demand of the payment of service charges upon our investments in a world of canalized trade have brought almost unbearable financial burdens on most of the republics. As a result, sometimes the governments used these regulations to discriminate against us.

The final word should be said about the foreign investments in Ibero-America. It is estimated that our direct investments amounted to $3,261,000,000 representing 45% of our entire direct foreign investment. These investments, even if they are temporarily unproductive, may in time become again profitable. Loans floated on the security of markets for Ibero-American governments, provinces and municipalities make up the other group of our investments totaling to over $1,289,000,000.[16] These fared even worse than the direct investments,

[9]Otto T. Kreuser, "Some Inter-American Financial Problems," *The Annals*, Vol. 204 (July, 1939), pp. 165-166.

since they were based upon estimates of national incomes made during high commodity prices. Only Peru and the Argentina federal governments were able to maintain payments throughout the depression. Venezuela had no external debts. The others suspended payments. A few receiving new "reorganization" loans have resumed payments, notably Brazil.[17]

Let us summarize briefly the obstacles of Inter-American trade:

(1) The southern republics produced a large share of the world's food products and industrial raw materials which suffered greater price depreciations than manufactured commodities; thus the Ibero-American purchasing power contracted disproportionately.

(2) Our Ibero-American import trade consists of mostly tropical foodstuffs and industrial raw materials. In both cases price depreciation does not stimulate consumption to any great extent. Thus, there is no compensating increase in the volume of our imports when Ibero-American purchasing power is reduced by falling prices.

(3) Our exports to Ibero-America are mostly luxury goods or capital goods which suffer a reduction before essential consumption goods do; thus, much of our trade losses following the depression were the result of the character of our exports.

(4) Our competitors, especially Great Britain and Germany, dominate the cheaper commodity categories, consumption goods or specialties; thus their losses were relatively smaller than ours. Great Britain even expanded her share during the depression.

(5) Increased industrialization of Ibero-America has reduced their demands for various simple manufactured products, especially, for textiles. On the other hand machinery sales increased. Industrialization ultimately will tend to increase Inter-American trade.

(6) Lack of understanding and appreciation of the Ibero-American way of living made us commit blunders; thus, some losses can be explained by our carelessness in selecting personnel.

(7) Ruthless competition, especially of Germany. Through barter trade and clearing agreements, Germany increased her share of Ibero-American trade. This competition against the United States was over-emphasized, because

(a) Germany had not reached her pre-World War level, whereas the United States surpassed it;

(b) the two countries cater to different groups of people; direct competition is restricted to a few groups of commodities in which we have the edge on quality, Germany on price;

[10]James S. Carson, "New Approaches in Inter-American Commercial Relations," *The Annals,* Vol. 204 (July, 1939), p. 69.

(c) the absolute gains of Germany were less than those of the United States;

(d) Germany actually expanded at the expense of Great Brittain; thus it was not the actual rivalry but the way in which the competition has been conducted that was objectionable. Barter trade and clearing agreements confer special privileges and contradict the principles of equality of treatment, the cardinal tenet of our trade policy.

(8) Great Britain and other lesser European powers succeeded in canalizing their trade; thus we were maneuvered into unfavorable positions by the bilateralizing of British and other European trade, especially in the case of Argentina and Uruguay.

(9) In Ibero-American countries, exchange controls were established on account of

(a) depreciation of export values;

(b) price differential between primary products and manufactured commodities;

(c) heavy foreign debt service;

(d) European exchange regulations;

(e) European efforts towards self-sufficiency;

(f) imperial and colonial preferences;

(g) cessation of foreign loans;

in order to

(a) minimize depreciation of home currency;

(b) conserve gold reserves;

(c) save credits resulting from export trade

(1) to meet the nation's foreign obligations;

(2) to confine imports to essential goods and services;

(d) free internal price levels from external fluctuations;

(e) prevent speculation and flight of capital.

To carry out this plan effectively foreign trade had to be brought under strict government supervision; thus the various governments can and do

(a) regulate the amount of exchange available for trade;

(b) prescribe the type of imports and exports;

(c) direct the flow of trade;

(d) select the merchants to carry out the transactions;

thus the governments of the exchange controlled republics have tremendous economic power which they wield occasionally against our best interests.

(10) In the face of all these obstacles, our steady gain in the share of the Ibero-American trade becomes still more remarkable, bearing testimony of our natural leadership in the Western Hemisphere, that shall never perish.

V. ECONOMIC DEFENSE

The present war has already altered the trade relations of Ibero-America. Germany has fallen out of the picture. Great Britain still carries on a part of her trade, but, in spite of the heroic efforts on her part, she is unable to maintain her regular trade relations. With the spreading of war to the whole continent of Europe, with the tightening of blockades on both sides, American supplies accumulate at an increasing rate. The United States, under the stimulus of war orders from Great Britain, does not feel the increasing pressure of stock accumulations. It is different in Ibero-America.

The present war differs greatly from the first World War. Then the belligerents were not well prepared for a long war. When it had become apparent that it was going to be a lasting war, the warring nations turned to the new world for food supplies and armaments. There came a great boom, prices soared and all types of production expanded at a rapid rate. Not until the last year of the war did the allies make really effective their threat of the blockade and succeed in stopping the flow of contraband.

In 1939 conditions were entirely different. First, before and during the depression, large surpluses of primary products have been accumulated. Second, since 1932 the great European powers had been gearing themselves for war. Led by Germany, Europe underwent an armament race unparalleled in history. However, not only did Europe arm, but every effort was made to accumulate surpluses of all kinds of materials for use during the coming war. Especially was this true in the case of Germany; but Great Britain and France acted similarly. Even we were establishing war reserves. The United States-British cotton-tin exchange had been one of the outstanding efforts in this direction. Not only did nations accumulate reserve stocks, but, on an ever increasing scale, they developed substitute products made from easily accessible and available raw materials, replacing goods depending on foreign raw materials. This increased self-sufficiency certainly had its effect upon the new world. Except for an initial flurry, there at present are no signs of a war boom. It is true, however, that our national defense program has not come into full force as yet. Let us hope that, aside from a welcome stimulus to business conditions, it is not going to lead into a war boom.

As far as Inter-American trade relations are concerned there have been a number of significant changes. Our share of the trade increased considerably both in percentage and in value. On the other hand, the continental trade has been lost. Of the European countries, only Great

Britain is able to maintain a fair proportion of her normal trade. This presents an extremely important problem.

Hitherto we looked upon Ibero-America as a market; now we have to see it as a source of goods.

TABLE 6*

DISTRIBUTION OF EXPORTS OF SELECTED IBERO-AMERICAN COUNTRIES
1935/37 average

COUNTRY	U. S.	U. K.	Japan	Germany	Other Europe	Cont. Europe	Others
Argentina	12.4	32.8	1.2	6.5	26.6	33.1	10.5
Bolivia	6.4	73.6	....	1.2	12.1	13.3	6.7
Brazil	38.1	10.0	4.6	22.7	16.0	38.7	8.6
Chile	21.6	17.8	1.3	8.7	14.1	22.8	31.5
Colombia	61.6	1.2	....	12.2	10.0	22.2	15.0
Costa Rica	44.7	23.0	0.3	11.9	8.2	20.1	11.3
Cuba	79.3	11.5	....	1.7	3.6	5.3	3.9
Guatemala	58.6	1.0	0.2	19.4	2.8	22.2	8.0
Mexico	59.9	8.1	1.7	9.0	11.9	20.6	9.7
Peru	20.7	22.2	2.7	12.3	12.5	24.8	29.6
Uruguay	13.6	24.9	6.2	13.1	5.6	18.7	36.6

*U. S. Department of Commerce, *Foreign Commerce Yearbook, 1938* (Washington, 1939).

For practical purposes we can assume that the trade of all continental Europe has stopped. That leaves from 1/5 to ⅓ of the normal exports unsold during the war. Only in the case of Cuba and Bolivia is the ratio of continental trade considerably lower. Venezuela is another exception. However, her export statistics are absolutely misleading, since over 70% of the exports (all petroleum) goes to the Dutch West Indies to be refined — a fact which distorts the true distribution picture. Most of the oil was used in Britain and on the Continent.

TABLE 7*

IMPORTS OF LATIN AMERICAN RAW MATERIALS IN 1937†
(in thousands of metric tons)

COMMODITY	United States	United Kingdom	Germany	France
Cacao				
Volume	129.9	7.2	19.2	3.0
% of total imports	46.3	7.5	21.4	7.2
Cattle Hides				
Volume	42.8	30.1	88.1	6.2
% of total imports	72.3	34.5	60.5	18.5
Coffee				
Volume	727.0	8.9	184.6	123.6
% of total imports	94.4	46.8	95.1	66.7
Copper				
Volume	155.3‡	123.1	36.0	37.6
% of total imports	85.5	29.7	11.1	28.2
Corn				
Volume	2,065.0	3,267.0	1,582.0	71.0
% of total imports	94.2	89.6	61.5	9.5
Nitrates				
Volume	635.8	47.5	105.2	83.1
% of total imports	85.4	88.3	100.0	65.4
Sugar				
Volume	2,020.3	1,212.5	3.6	224.3
% of total imports	69.7	52.4	37.5	57.9
Cotton				
Volume	.....§	111.2	110.9	22.4
% of total imports	.....§	14.3	25.2	7.6
Wheat				
Volume	.....	801.0	550.0	16.0
% of total imports	.....	16.3	37.3	3.5
Wool				
Volume	32.1	46.6	33.3	25.8
% of total imports	24.1	13.1	26.3	16.9

*H. J. Trueblood, "War and the United States Latin American Trade," *op. cit.*, p. 220.

†Computed from League of Nations, *International Trade in Certain Raw Materials and Foodstuffs*, 1937.

‡Largely re-exported.

§Since the United States is a heavy exporter of raw cotton, small imports from Latin America are of no significance.

That leaves the question: Could we absorb all these surpluses? There is no all-inclusive answer. Wheat, corn, cotton, meats, petroleum, bananas, and sugar are important commodities which we either cannot import at all, or can import only in small quantities, or of which we are already buying all we use from Ibero-American sources. (Table 7). This affects Argentina, Brazil, the Central American Republics, Colombia, Cuba, Peru, Uruguay, and Venezuela. Chile and Bolivia could increase the export of their present chief commodities,

since there is an increased demand by the United States for copper and a moderately increased one for nitrates. The staples of the other republics could hardly be sold in our market in any increased quantities. There the solution lies in the diversification of their production. There are large resources which at present are not utilized at all, or which are utilized only to a rather small degree. If trade levels are to be maintained under the present circumstances, a diversification of Ibero-American production is absolutely essential.

This diversification, however, cannot take place immediately, but the needs are immediate. Our external trade for the period of September, 1939, through August, 1940, reached a "favorable" balance of almost $1,400,000,000, its highest peak since 1921. Exports rose above 4 billion dollars, showing a gain of 37% over the like period a year before. Imports rose to $2,600,000,000, representing an increase of 23%. This was an interesting deviation from our experience of the first year of the World War when we lost 13% of our imports.[11] The increases in both instances are caused by our sales of war materials to Great Britain; thus it did not materially help the situation of the accumulation of non-war supplies in Ibero-America.

These accumulations may further react unfavorably upon the price structure of the leading non-mineral exports of Ibero-America, causing a retrogression of their purchasing power. This is especially true in the case of Argentina, Uruguay, and, to a lesser extent, Brazil —in which countries agricultural products dominate their foreign trade.

Tin producing Bolivia is going to face difficulties similar to those of the agricultural countries. In this respect it would be highly advisable to establish a tin smelting industry in the United States, especially if we take into consideration the rather doubtful political situation of the Orient. It certainly would ease the difficulties of Bolivia which country could probably supply us with ⅓ of our present demand.

As far as Cuban sugar is concerned, the situation is not too critical. The United States takes 80% of her exports, while almost all of the rest goes to Great Britain. Even if the German blockade were successful, we could take over the surplus of the island republic's exports without serious damage to anybody, including our various sugar interests.

Our imports of cacao could be increased, since Ilbero-America supplies less than half of our imports. Similarly, we could buy more wool from there. However, we have to remember that there are quality and price differences which complicate the matter considerably. The

[11] *Gainesville Daily Sun,* Nov. 20, 1940, p. 1.

bulk of our cheap grade cacao comes from the Gold Coast, while only the finest qualities come from South America and Trinidad. In the same way, quality variation makes it necessary to import many kinds of wool which South America alone cannot produce.

For the rest of the commodities other methods have to be devised during the present emergency. The fact is that the continental trade which absorbed 37.6% of the Ibero-American exports has been temporarily lost; even Great Britain may not be able to maintain her 16.8% share of Ibero-American exports. Some of this has turned to us, but, even under very favorable conditions, between 25 and 33 percent of the exports of the southern continent have lost their markets. It is true that this loss is temporary, yet the emergency of the present moment is little alleviated by the hope that peace finally will come to the world.

Peace, nevertheless, will come; and, when that happens, the hungry millions of war torn Europe are going to need the food and other products of the Western Hemisphere. Consequently, our policy should be formulated according to this outlook. The situation is that the United States, Canada, and Great Britain are unable to absorb all the Western Hemisphere production. After the war there will be a great demand for all we have. There is, however, the gap between today and the peace to come, a gap that has to be bridged. Why not store today's surpluses for tomorrow's use?

There are only two immediate possibilities. One would be the curtailment of the production of wheat, coffee, cotton, and other non-war demand commodities. Such a policy would be distinctly unsocial, inadvisable, and not enforceable. The other possibility is the creation of a Hemisphere Surplus Commodity Cartel, which would take over somewhat below current prices that share of the countries' normal production which could not be sold on account of the lost European market. Or if the actual purchase of these goods would be impractical, then the cartel would lend against the unsold commodities 10% to 25% below their current market price. Whenever the commodities became saleable then the cartel would effect the sales, charging a minimum interest, about 1½ to 2% per annum against the sale price of the commodity, and, would turn over to the producer the balance between the sale price on one hand and the interest and original price on the other. If the cartel did not actually take over the commodities but advanced loans against them, then, at the sale of these commodities, the loans, with small interest, would become due and would be repaid.

The capital of the cartel would have to be calculated with great care. The period of its existence would naturally depend upon the magnitude of its task. Studying the figures of export trade would

give an idea of the amount of capital needed. Taking the 1938 figures as a base for a rough calculation, we find that $691,000,000 worth of goods were exported from Ibero-America to Europe, excluding the United Kingdom and Russia. Naturally, some of these commodities will find markets in North America; some shifts are going to occur in production which will actually reduce this figure. On the other hand certain types of North American export commodities are going to lose their European markets. These changes will compensate one another, so that it would be possible to count on about 350 million dollars' worth of unsaleable commodities.

Another question is the probable life span of the cartel. Here we deal with unknown quantities, but, even if the war were to come to an unexpectedly early termination, we can safely assume that the complete liquidation of the cartel would not come before 1945/46. Since over-capitalization would unnecessarily increase the cost of the whole plan an initial capital of $500,000,000 should be ample. If this proved insufficient in the future, further capital could be made available to the cartel.

Each Western Hemisphere country, including Canada, would participate in the cartel. The capital would be raised in proportion to the population and to the share in the hemisphere trade of the respective countries. Since the cartel would be a non-profit organization, no more than one-half of one percent annual interest would be given to the participants. The interest charged against the producer might not pay the expenses. In this case, a tax could be levied against those commodities which find ready markets and which enjoy war time prosperity. This tax, however, should be levied according to the total cost and not the cost of the individual country. It may well be that in our unity we should help each other in an unselfish way, fully realizing that whatever helps our neighbor is ultimately helping us.

Through the good offices of the cartel, a great disparity of commodity prices could be eliminated. Food producers would be saved from great losses resulting from speculative price manipulations. By careful selling or buying as the occasion demanded, unnecessary and dangerous price inflation or deflation could be avoided. Naturally, it should be the policy of the cartel to do everything possible to prevent the accumulation of too large stocks. To achieve this end, a plan would have to be devised, based on the production data of the last twenty years, which will guide the cartel and the governments of the participating countries in establishing a quota system for the production of the commodities which come under the protection of the cartel.

By no means should it be permissible to use the loans for the expansion of the production of the protected commodities. On the con-

trary, the cartel, that is its local, national or regional branches, should study the possibilities of diverting some of the productive efforts of the people from the protected commodity towards the production of the other types which would find ready markets in the Western Hemisphere at present, and which would later expand into the rest of the world. Thus, with the aid of the cartel, we would be able not only to remedy the loss of the continental markets but also aid and direct the much-needed diversification of Ibero-America.

Another step in this direction would be the establishment of a permanent Inter-American economic council. This council should be constituted of the representatives of the various branches of business, as well as trained research workers in the various fields of economics and related sciences, of each of the western hemisphere countries. The council through its affiliated national organizations should study the economic needs and possibilities of the various countries. The results of these studies and investigations should be published and made available to all interested. It should be the duty of the council to make recommendations for desirable economic legislation. The various governments should consult the council before recommending or endorsing important legislation, especially, if it is going to affect infra-hemisphere economic relations. The council should be in charge of an integrated economic educational program. It should sponsor conferences and forums, and use any other means for the dissemination of objective economic information.

With the aid of the council, and possibly through the services of the cartel, a new investment policy should be inaugurated. Since our direct investments represent working capital, some of which is idle and unproductive on account of the depression, it could reasonably be expected that, with the improvement of general economic conditions, most of them would become active and profitable once more. If, however, on account of overcapitalization or for some other reason, a reorganization seemed advisable, it should be effected with the financial aid of a Hemisphere Bank. The bank should be in charge of (1) liquidating or reissuing defaulted governmental and municipal bonds, (2) giving long term credit to assist the various governments in eliminating exchange control measures, (3) giving any financial assistance which is beyond the scope of the national banking systems of the republic.

The capital of the bank would be furnished by all countries of the Western Hemisphere. Since we are the richest nation in the Western Hemisphere, since we have carefully hidden 75% of the world's monetary gold under the ground, it would be advisable to dig up some of it and use it for some productive purpose; thus we should subscribe

to ⅔ of the one billion dollar capital of the bank. The other ⅓ should be divided between the other countries in proportion to their population, wealth and resources. If any of these countries were unable to provide its share of the capital, we should lend as much as needed to the country at not more than ¼ of 1% interest. The interest rate on the capital stock limited to a maximum of 3%.

It is highly desirable that the Ibero-American republics should participate to a considerably higher degree than at the present in the development of their latent resources by increasing their own share of the capital invested in their respective countries. To bring about an active participation in the economic development of the republics, and thus to forestall the accusation of foreign exploitation and prevent the danger of expropriation of foreign investments, it is proposed that the interest rate on the capital invested in the Hemisphere Bank should be kept at 1% for fifteen years. The difference between the maximum interest rate and the actual one, plus other profits that may occur should be divided between the participants, except the United States, in proportion to their capital investments. This surplus dividend should be used first to repay the original loans of the United States, if there had been any, and second, it should be funded as capital stock in proportion to the original capital of the participant countries, save the United States, until their capital investments might reach a level proportionate to their population, wealth, and resources. After such a balance has been reached all differential payments should be discontinued.

The Hemisphere Bank, like the cartel, should be not primarily a profit making enterprise but a service institution. Its main aim should be to facilitate the economic development of the hemisphere, to overcome financial obstacles and difficulties hampering the full development of the countries involved, to guide and regulate investment policies, to inaugurate and aid the evolution of a sane exchange policy in the Americas.

Unwise lending and investments bring only temporary relief and a false boom. Thus a lending policy is not sufficient by itself. We have to change our commercial policy. Unless we buy more from the world at large than we sell them, our investments will remain barren. We must increase our purchases from Ibero-America if we hope to collect profits on our investments. The more we invest the more we have to buy. We must discard our "debtor nation" psychology. We must realize that only by buying more from them can we sell more to them.

Through increased purchases, and by the establishment of the cartel and the bank, we can face the war time emergency and prepare for peace. However, there is the question of the peace. There are three

possibilities: (1) the axis is defeated; (2) the war ends in a stalemate; (3) the axis defeats and subordinates Great Britain. The first possibility simplifies our problem. The second would signify a concentrated effort by the axis and the democracies to gain economic control and the ensuing political dominance of Ibero-America. In this case our position is strong. In the past the United States and the British Empire held an overwhelming economic dominance in Ibero-America. Unless the British trade with Europe were shattered the problem boils down to an economic co-operation between the democracies and the establishment of a co-ordinated trade policy. If, however, the axis were to dominate European economy to the exclusion of Great Britain then the survival of the British would not safeguard our position in Ibero-America, since most of the British trade was either purely of the entrepot type or meant the importation of raw materials and the export of British manufactured goods. If Germany would be able to assume this role, then our economic position would be greatly altered, and the problem would become synonymous with the last potentiality.

The third possibility presents the real problem. Not only the economic significance of Europe, but the psychological effect of an axis victory, may change the present setup in its entirety. To prevent such an emergency we have to (1) continue our co-ordinated defense system with the rest of the hemisphere, and temporarily assume the protection of all the hemisphere; (2) continue to give sufficient financial assistance to the other countries to enable them to build up their defenses; (3) maintain through the cartel the close economic unity whereby Europe has to deal with the Western Hemisphere as one body and not with the single individual countries.

Before we can continue further we have to re-examine our economic position in its world relationship. First, we notice that the seven chief Ibero-American countries (exclusive of Mexico) purchase slightly less from us than the ten erstwhile small democracies of Europe. Our relative position is much stronger in the Ibero American countries than with the small countries of Europe. The three continental powers combined almost equal the first two groups, and our relative strength is about the same as in the case of the small European countries. The United Kingdom is by far our best customer, followed by Canada and Japan. The first two buying more from us than any other group, and Japan buying more than France, Germany and Italy put together. Our exports to Canada and the Ibero-American group with Mexico are about equal. As far as our relative strength is concerned in the European countries and the United Kingdom, we supply about 10% of their imports. In that respect Argentina resembles

Europe. In the Caribbean republics and Canada our predominance is unquestionable. In Japan, the West Coast republics and Brazil we supply ⅓ of their imports.

TABLE 8*

VALUE AND PERCENTAGE OF THE IMPORTS FROM UNITED STATES OF SELECTED COUNTRIES, 1937

Name of Country	Ibero-American in $1,000	Percent of total imports	Others in $1,000	Percent of total imports
Argentina	76.829	16.9		
Belgium			**80.527**	**8.8**
Belgium			*80.527*	*8.8*
Netherlands			*75.052*	*8.8*
Chile	25.711	29.1		
Norway			*27.399*	*8.5*
Columbia	46.394	48.3		
Czechoslovakia			*33.576*	*8.8*
Hungary			*6.314*	*4.5*
Cuba	88.847	68.6		
Sweden			*75.728*	*14.0*
Ireland			*14.359*	*6.6*
Peru	20.976	35.3		
Denmark			*20.490*	*5.5*
Venezuela	45.452	52.8		
Finland			*18.253*	
Switzerland			*28.944*	*7.0*
Seven Chief Ibero-American Republics	380.619			
Mexico	109.850	62.7		
Small democracies of Europe			*380.789*	
France	160.713	9.5		
Germany	113.506	5.2		
Italy	79.496	10.9		
Total European Powers			353.715	
United Kingdom			564.847	11.1
Canada			489.997	60.6
Japan	365.502	33.6		
China	55.291	9.5		
Total			420.793	
U. S. S. R.			47.819	

*U. S. Department of Commerce, *Foreign Commerce Yearbook 1938* (Washington, 1939).

Thus there are six groups of nations or individual nations, which take about equal shares of our exports—roughly, about 15% each. Of these, in two groups and one individual country, our relative position in trade is weak. Of special importance to us are our continental customers, purchasing about 30% of our exports. This is the trade we

lost on account of the war. This is the trade which will be hard to regain if the axis powers win, especially if Great Britain were to fall—an event which would increase our loss to 45%. It is a disturbing picture. If we add to it Canada's and Ibero-America's share, it looks even worse.

Looking at it from another angle, we find that the democracies control half of the world's imports and more than half of the exports.

TABLE 9*

PERCENT OF WORLD TRADE: IMPORTS AND EXPORTS OF SELECTED COUNTRIES. 1935-1937 AVERAGES

NON-TOTALITARIAN			TOTALITARIAN		
Countries	Imports	Exports	Countries	Imports	Exports
United States	11.0	12.0	Germany	7.9	9.2
Argentina	1.8	2.8	Italy	2.9	3.3
Brazil	1.1	1.5	Japan	3.7	3.7
Canada	2.8	4.2			
Chile	0.3	0.6	TOTALITARIAN	14.5	16.2
Colombia	0.3	0.4			
Cuba	0.5	0.7	Belgium	3.3	3.3
Mexico	0.6	1.0	Czechoslovakia	1.4	1.6
Uruguay	0.2	0.2	Denmark	1.4	1.5
Venezuela	2.7	1.0	France	6.6	4.6
			Netherlands N. Indies	3.7	4.1
United Kingdom	18.5	12.0	Norway	1.0	0.8
Australia	1.9	2.4	Poland	0.9	0.9
Canada	2.8	4.2			
India	2.2	3.2	TOTALITARIAN Controlled Europe	18.3	16.8
British Malaya	1.3	2.9			
Union of South Africa	1.7	0.8	TOTALITARIAN	14.5	16.2
New Zealand	0.8	1.0	TOTALITARIAN CONTROLLED EUROPE	18.3	16.8
BRITISH EMPIRE	29.2	26.5			
North America	16.3	20.0	ALL TOTALITARIAN	32.8	33.0
South America	4.5	7.2			
WESTERN HEMISPHERE	20.8	27.2			
BRITISH EMPIRE	29.2	26.5	U. S. S. R.	1.0	1.5
			China	1.3	1.0
DEMOCRACIES	50.0	53.7	Others	14.3	10.8

*U. S. Department of Commerce, *Foreign Commerce Yearbook 1938* (Washington, 1939).

Except for Great Britain they are all young countries, rich, under-populated, and controlling the major share of the world resources badly needed by all Europe, whether free or oppressed. This

is an important factor in our favor. The axis dominated world is poorly endowed; it is using every last scrap of resources; it cannot feed itself. On the other hand, the democracies kill baby pigs, plow under almost anything, burn coffee, destroy rubber trees, restrict the mining of copper, tin, and nitrates. There is no question that we have the upper hand. Even if the many predictions about the collapse of the German economic system were mistaken, ultimately Europe cannot stand isolated. There is a limit even to the endurance of the Germans. The key is in the hands of the U. S. S. R., for only with the aid of the Russians can Europe continue fighting for a long time to come, and even this is possible only if the U. S. S. R. can be organized effectively. The past purges and sabotage trials seem to indicate the opposite.

Since the economic position of Britain is at least partly European, even the fall of Britain would not alter the material distribution of resources. If the Empire remains independent, we still retain the upper hand. The fall of Malaya and Netherlands India, and, as a matter of fact, of India itself, would not alter the situation greatly. The loss of tin and rubber would cause temporary inconvenience, but, after all, the axis could not hoard them indefinitely if it wants to profits by its conquest. Furthermore, neither rubber nor tin are absolutely essential. Synthetic rubber and Brazilian production could replace Malay rubber. Bolivia could supply the essential amount of tin; for the rest, substitutes could be used.

The real strength of the democracies lies in the Western Hemisphere. That we must defend. Only through the domination of South and Central America could the axis powers really harm us. It is our own selfish interest that motivates us to become unselfish. Only through sacrificing some of our egoism can we save our way of living, can we show the road to that future life which should be the reward of "the pursuit of happiness."

This is not intended to mean that we should not do everything in our power to help the British in their valiant stand of self defense. We may have disagreed on many points of policy, but they are now defending their way of life and their home against the invasion of hostile forces. Their way of living is kin to ours. If they fall, it may become our undoing. So help we must. Yet our strongest line of defense is at home.

We have to build up American solidarity now. We have to gain the favor of all the peoples of the western hemisphere. We have to be ready for any eventuality. If Britain is meant to fall, or even if she comes out alive but greatly weakened, we have to be ready to face

Europe, help them to get peace, but at the same time jealously guard our institutions, and help and encourage our friends.

The rivalry could become extreme. After all even we cannot afford to waste precious resources indefinitely. When peace comes, our responsibilities will become tremendous. It is in our power to make or break the peace. Once we did not make it. Now we shall have to make amends. Against the axis we have to defend ourselves and our neighbors to the north and south. Because of reopened competition, it is going to be a harder task in peace than it is now.

Our economic assistance and collaboration has to be extended. All of us have to cooperate to the fullest to present a common economic front against the regimented front of axis dominated Europe. The scope of the Hemisphere Surplus Commodity Cartel has to be enlarged to include all commodities. This will establish a central brokerage house through which we can trade with the axis powers without exposing any one of us alone to the dangers of economic exploitation.

This sounds pessimistic, but in reality, it is not. We have to defend ourselves; thus, we must be prepared. If we are prepared we can face the future on equal terms with any hostile combination. That is why we need the strong economic cooperation in the Western Hemisphere. That is why we need the cartel, the bank. That is why we have to buy more from the world; only by buying more can we sell more. Increased trade means increased profits; increased profits mean increased purchasing power; increased purchasing power brings forth higher standards of living; that means prosperity, and prosperity is peace.

We need, furthermore, a better understanding of each other. We need more contacts between our peoples. We have to expand our plans for the exchange of students, professors, businessmen and intellectuals. We should travel more in Central and South America. Travel to see how they live, to study their economic and political conditions, meanwhile refraining from freely-given, unsolicited advice and criticism. To know is to understand, to understand is to appreciate. We badly need more knowledge, understanding, and appreciation of Ibero-America, and, as a matter of fact, of the whole world. If we can achieve all these, we need not worry. No -ism will be strong enough to undermine the solid foundations of a true and sincere American solidarity.

THE ANGLO-FRENCH RIVALRY IN SIAM, 1902-1904

G. Leighton LaFuze
Stetson University

The Anglo-French rivalry in Siam developed as a result of French and British expansion in Indo-China and the Malay peninsula during the latter half of the nineteenth century. Situated in the heart of southeastern Asia, the Siamese kingdom was, after 1885, a solitary and helpless country confronted by French Indo-China on the east and by British Malaya and British Burma on the south and west. In 1885 the British conquest of Theebaw's kingdom, Upper Burma, and France's completion of her occupation of Tonkin and Annam heralded a more acute period of imperialistic rivalry.

The British, however, were able to maintain their position of dominant influence in Siam. They controlled most of the trade, shipping, industry, and capital and anticipated a profitable exploitation of the kingdom's largely undeveloped resources, which included fertile land for rice culture, valuable teak forests, and minerals. Of the latter, tin was to prove the most important. Moreover, Siam offered an approach to southwestern China, with which British and French alike hoped to develop a valuable trade. British political and cultural forces also predominated. Most of the numerous foreign advisers in the Siamese administration were British subjects, many Siamese princes and noblemen were educated under British tutelage, and English became the language of society and government in Bangkok, the capital and principal city. In addition to these varied interests, British statesmen valued Siam as a buffer state of the Indian empire: an eastern counterpart of Afghanistan. At the same time they were prepared to deprive Siam of valuable territory bordering Burma and British Malaya.

With less significant economic and political stakes in Siam, the French were nonetheless attracted by her great wealth. In 1893 their attempt to occupy Siamese territories east of the Mekong River resulted in an undeclared war with Siam and in effective diplomatic intervention on the part of Great Britain. France had to content herself with limited territorial and other concessions. On January 15, 1896, was concluded an Anglo-French agreement by which the two countries recognized the Upper Mekong as the boundary between Burma and Tonkin and guaranteed the neutrality of the Menam basin, the most valuable part of Siam. By implication the remaining por-

tions were to become effective spheres of influence. Great Britain, however, refused to interpret the agreement in this light. She further safeguarded her interests in the Siamese Malay states by forcing upon Siam the secret treaty of April 6, 1897, forbidding the granting to a third power of any territory or concession affecting the regions south of Bang Tapan.

During the interval between the signing of the declaration of January 15, 1896, and the conclusion of the *Entente Cordiale* on April 8, 1904, old and new forces were shaping the Siamese question in ways somewhat strange to historic Anglo-French rivalry. Certain developments in Siam and in outside interests added new factors to the situation. Nor were the older imperialistic influences by any means dormant. In 1902 the colonial authorities of Singapore initiated an aggressive action against Siamese Malaya which the British Foreign Office was prevailed upon to support. Almost simultaneously the discontent of powerful British teak companies and British Asiatic subjects helped to instigate and prolong a revolt in the northern provinces which gravely threatened both the internal and the external security of Siam. Between that kingdom and France, acute tension still continued; and the French government undertook the difficult task of realizing in some measure the demands of French Indo-China without arousing dangerously the susceptibilities of Great Britain. Finally, the controversy over Siam, like other imperialistic issues, was subordinated to the exigencies of general policy; and the declaration of 1904 "settled" the question by the familiar method of compromise, satisfying in realistic fashion the most impelling desires of the powers.

NEW FACTORS IN THE SIAMESE QUESTION

At the turn of the century British economic enterprise in Siam was encountering a formidable and growing competition from the Germans. Great Britain's share in the shipping trade of Bangkok fell from 357,048 tons or 78.8 per cent of the total in 1898, to 65,511 tons or 11.2 per cent of the total in 1903.

Energetic German industrial and commercial firms, supported by tactful but effective aid from their government, gained an increasing allotment of the good things offered in Siam to western business men. The Germans, moreover, were second only to the British in the number and importance of the posts they enjoyed in the Siamese administration.

Although this appearance of Germany on the scene was important, the results were confined to a limited field. Yet British interests were aroused. To them Germany appeared more dangerous as an economic rival than France was ever likely to become. The French were

concerned mainly with the comparatively unproductive Mekong valley; and as the British began to think of a general entente with France, it seemed quite appropriate to include a program of Anglo-French cooperation in Siam against Germany.

Unless, however, a satisfactory solution could be reached with France, the British had grounds for fearing that Siam's independence might be imperiled by action of the French colonials, who had not renounced their long cherished designs, and who were ready to ignore with impunity the prohibitions of the declaration of 1896. British interests feared that the Bangkok-Korat railway, completed in 1901, might serve to facilitate the execution of the French colonial program. As Rivett-Carnac, the British financial adviser to the Siamese government, cogently expounded the theory in his minute of February 13, 1902, if the French should seize Korat, which lay within their sphere of influence, they might use the new railway to occupy Bangkok itself.

Another new factor was the virtual abandonment by Great Britain of the historic quest for the trade of Yunnan and South China from the direction of Burma and Siam. In 1901 Burma completed a railway to Kunlong on the upper Salween River near the Chinese frontier; but formidable physical obstacles would hinder its extension, and Lord Curzon, Viceroy of India, in a speech at Rangoon on December 10, 1901, took occasion to denounce the still popular idea of developing a lucrative trade by rail with the provinces of South China. Thus the Upper Mekong region became still less important to the British. Curzon's announcement pleased the French; henceforth they were free to carry out in a clear field Governor-General Doumer's far-reaching plan for the extension of the Hanoi-Laokai railway to Yunnan-fu. China finally awarded the contract for this line on October 29, 1903.

Another novel factor in the Siamese question was the role assumed by the Japanese government, which had concluded a treaty of friendship and trade with Siam on February 25, 1898. Naturally desirous of advancing friendly foreign interests, Siam was especially attracted to this Oriental power, capable of dealing on even terms with the forces of European imperialism. By 1901 Japanese influence in Siam had to be reckoned with: several Japanese enjoyed posts in the Siamese administration, and the Japanese were sponsoring a plan to establish sericulture in the Mekong valley. In 1902 Siam was strengthening her military forces with the aid of Japanese officers and equipment.

This entire development was regarded by the French with keen anxiety. On September 28, 1901, and again on May 15, 1902, Klobuk-

owski, the French minister in Bangkok, warned the Siamese government that France would consider as an unfriendly act any attempt to carry out public enterprises under foreign management in the Mekong valley. After the announcement of the Anglo-Japanese Alliance Treaty of January 30, 1902, Klobukowski was convinced that the signatory powers had already been cooperating successfully to prevent him from making a settlement with Siam. French predominance in the Mekong valley appeared to be threatened, and Klobukowski feared that if Japan's policy should be logically developed, the security of French Indo-China would be endangered. Before the potent influence of the Anglo-Japanese combination, to which Siam willingly resigned herself, France might be obliged to abandon completely her contemplated role as an equal partner in a condominium over Siam.

In fact Lord Lansdowne, the British foreign secretary, prompted by several members of the Salisbury cabinet, had made every effort to include India, Siam, and British Malaya in the scope of the alliance; but although Hayashi, the Japanese ambassador, appeared to favor such a stipulation, the Japanese government declined to undertake so burdensome a responsibility. Klobukowski was nonetheless correct in asserting that the alliance was directed against France and her ally, Russia, in Asia. Its existence impelled the French government to seek a speedy settlement with Siam; while colonial officials, to whom the danger appeared more real, took the precaution of increasing the military forces in French Indo-China, a measure which the outbreak of the Russo-Japanese War in February, 1904, seemed to justify.

THE AFFAIR OF KELANTAN

For years the enterprisers and officials of British Malaya had been discontented because the British government refused to sanction any attempt to obtain political control of the adjoining Siamese states. Possessing much gold, tin, and rich land, these regions also offered suitable railway routes. Especially desirable were the states of Kelantan and Trengganu located north of Pahang on the east side of the peninsula.

The Kelantan affair originated with the activities of R. W. Duff, an ardent promoter of British enterprise. Having organized a company in 1900, he entered Kelantan in defiance of Siamese authority and later obtained from the frightened native sultan a concession involving administrative powers and exclusive commercial rights over some three thousand square miles of the state's richest land. During 1901 and 1902 the British government sought to obtain Siam's recognition of this amazing contract and further demanded that British subjects be appointed as residents or advisers in Kelantan and Treng-

ganu. Such residents, although nominally in Siamese service, were to possess full powers and were to be appointed and removed only with Great Britain's approval.

Siam vainly sought to temporize or compromise, and in the summer of 1902 the situation became critical. Confronted by the open hostility of British Malaya, in danger of losing control over Patani and other border states, the Siamese government sent a special envoy to Europe. In August a clash occurred between Siamese sailors and some of Duff's men in Kelantan, promptly followed by the arrival of a force of British Sikhs allegedly sent to protect the sultan. On August 22 Siam received an ultimatum. Obligated to capitulate, she concluded a secret agreement in October embodying the British terms. Although she asked that it remain unpublished, its substance soon became known.

By her policy in the Kelantan affair, Great Britain estranged Siam at a time when the latter was anticipating another crisis with France. Rivett-Carnac, who saw the coveted post of general adviser go to Edward Strobel, a faculty member of the Harvard Law School, told the American minister in Bangkok "that not for a generation had the interests of Great Britain received such a set-back in Siam." As anticipated, French organs raised a furor, rejoicing that at last Siam could recognize the hypocritical nature of Great Britain's friendship, and calling upon their government to follow the British example. In short, the British had abandoned their role as protectors of Siam, had invited the French to renew their aggressive tactics, and had made desirable a closer understanding between the two powers regarding their interests in that kingdom.

THE SHAN REVOLT IN NORTHERN SIAM

Perhaps it is something more than merely a coincidence that an uprising of the Shans almost paralyzed Siamese authority in the regions of Pre, Lakon, and Nan, during the last six months of 1902. Although the background is not clear, it appears that the revolt was instigated by British Burmese Shans, supported by powerful British companies engaged in the teak industry, and furnished with munitions and supplies from British sources. During the revolt, which Siam curbed with difficulty, the persons and property of British and French Asiatics suffered injuries, sometimes at the hands of Siamese soldiers. Many fleeing Shans crossed into French Indo-China. French and British interests loudly clamored for intervention, charging that Siam was incapable of maintaining order in her northern provinces.

Despite Siam's well-reasoned misgivings on this score, matters did not come to such a pass; although the American minister has re-

corded his mature opinion that the revolt "very nearly cost Siam the greater part of her northern territory." The affair served to intensify Siam's distrust of the British, afforded an occasion for something like Anglo-French cooperation in Siam, and pointed toward further collaboration of the two powers. In view of British conduct in the affairs of Kelantan and the Shan uprising, it is not surprising that Lansdowne answered the Siamese envoys' plea for a joint guarantee of Siam's integrity with the observation that there appeared "to be considerable objections" to the conclusion of such an arrangement.

THE FRENCH SETTLEMENT WITH SIAM

The persistence of France in maintaining her absurd interpretation of the agreements of 1893, the aggressive and outspoken views of French colonials, and the refusal of Siam to compromise with a government whose intentions she rightly distrusted, maintained a state of acute but barren friction between France and Siam. The chief subjects of controversy were protégés, the neutral zone, that part of Luang Prabang lying on the right bank of the Mekong, and the continued occupation of Chantabun by French troops.

During 1901 and the first half of 1902, Delcassé, the French foreign secretary, and Klobukowski sought unsuccessfully to settle these and other issues in a manner wholly favorable to France. Alarmed at the Anglo-Japanese alliance, Klobukowski, in June, 1902, urged immediate occupation of the Mekong valley. Recalled to Paris, he asserted in September that the British so controlled the Siamese administration that they could easily establish a protectorate over the kingdom.

Delcassé now changed his policy. He determined to sacrifice colonial interests and the agreements of 1893 in order to effect a *rapprochement* with both Siam and Great Britain. In July the semi-official *Temps* expounded this new policy. France, it declared, must adopt the part of a good neighbor in order to share with Great Britain in the development of the Menam valley, a region of far greater consequence than the unfertile districts of the Mekong basin. Only by gaining the confidence of Siam could France expect to attain her role as an equal partner under the Anglo-French agreement of 1896; only in that way could British domination be altered.

Being as yet unable to count on Great Britain's good will, Delcassé found it expedient to be remarkably generous with Siam. Hence, the convention of October 7, 1902, accorded advantages to Siam as well as France.

Toward this settlement the British government at first adopted an attitude of reserve. On October 22, however, Lansdowne formally protested that the treaty encroached on British rights in certain respects, and that it placed "France in a privileged position," enabling "her to dominate by her influence the central portion of the Siamese Kingdom." Great Britain therefore might have to consider her own interests and modify existing treaties, with special reference to the Malay Peninsula. Lansdowne did not conceal the fact that both he and the Siamese government really desired the speedy ratification of Delcassé's treaty; until that should be accomplished, he would not consumate any new arrangements with either France or Siam.

This last statement was a great blunder on Lansdowne's part, for it put Delcassé on his guard and helped to insure the abandonment of his treaty. In his dispatch of November 6th Delcassé remarked that Lansdowne had not divulged his intentions regarding Malaya and that he evidently desired to keep France in the dark; for if his plans were known, France would be impelled to seek greater concessions from Siam. Lansdowne must understand that France could not accept an Anglo-Siamese treaty more advantageous than her own.

On November 19, Cambon, the French ambassador, frankly told Lansdowne that the treaty should satisfy Great Britain, since it would contribute greatly to Siam's stability. If the British subsequently should wrest greater concessions from Siam than Delcassé had obtained, the latter would be exposed to embarrassing attacks from French colonials and nationalists. But Lansdowne was not to be moved. He still contested the claim that France might make the Mekong valley her sphere of influence; as for British intentions regarding Malaya, he intimated that they were not a matter with which France had any concern. Delcassé therefore was driven to reconsider his treaty.

Two other factors dictated the same policy. For one thing the French parliamentary and press opposition proved unexpectedly formidable. The colonials raised a tremendous furor, applying to the convention such term as "a second Fashoda"; some apparently thought it the most disgraceful treaty since that of Frankfort in 1871.

The Siamese, moreover, still under the spell of traditional French policy, and constantly reminded that their French colonial neighbors had lost none of their immoderately aggressive spirit, failed to meet Delcassé in a friendly manner. Consequently, after reaching a preliminary entente with Great Britain, Delcassé insisted upon a new settlement with Siam. Now completely deserted by the British, and deeply perturbed at the changed attitude of Delcassé, Siam reluctantly accepted his new terms.

The resulting treaty of February 13, 1904, signed in Paris, was less harsh than might have been expected by Siam. She was obliged to yield the district of Krat and the remainder of Luang Prabang. She consented to the building of a railway from Battambang to Pnom-Penh, the capital of Cambodia; only local police were to be used in Angkor and Battambang, and they must be commanded by French officers. The article regarding French economic domination of the Mekong was fortified; and France obtained slightly better terms than in the convention of 1902 for her protégés. In most other respects the terms of that convention were maintained.

THE *ENTENTE CORDIALE*

The *Entente Cordiale* of 1904 was concluded chiefly because of the general desirability of Anglo-French cooperation regarding Morocco, Egypt, and Siam. Its chief architects were Delcassé and his able ambassador in London, Paul Cambon. By the summer of 1902 they were prepared to open negotiations in earnest.

On August 6, 1902, Cambon took up the subject with Lansdowne in his own inimitable way. Having first observed that France was no real political, commercial, or naval rival of Great Britain, he affirmed that she now desired to maintain the *status quo* in her colonial empire. Morocco and Siam were the only points which needed attention. With respect to Siam, it was necessary merely that the rights of both parties under the declaration of 1896, which had divided the kingdom into spheres of influence, should be more explicitly defined; and that arrangements should be made to prevent the Germans from profiting by existing Anglo-French friction to secure a possible basis for intervention in the Menam valley.

Lansdowne immediately asserted the validity of Salisbury's interpretation of the 1896 agreement. In reply to his question, Cambon said that in her sphere of influence, France must have a free hand in regard to police protection, control of railway construction, priority in mining, and other concessions, and the right to appoint such officials as she might find expedient. Actual occupation was not called for; Siam might remain the nominal sovereign and collect the revenues. Great Britain should enjoy similar privileges in western Siam and in the Malay Peninsula.

It may be observed how subtly Cambon played on British anxiety about German competition. France really feared Japan, not Germany. While minimizing and misrepresenting the problems involved, the French ambassador frankly admitted the scope of France's ultimate demands. He thus allowed Lansdowne to perceive the final objectives of French policy, which far transcended the rather prosaic terms

of Delcassé's first convention with Siam. Realizing that in this game over Siam the advantage was all on his side, Lansdowne made the most of his opportunity by hindering Delcassé and by concealing his intentions regarding Malaya.

For France, in fact, the question of Siam was admittedly second in importance only to that of Morocco. Curiously enough, the most compelling demand for an entente came from clear-sighted French colonials, whom Delcassé was obliged to heed. Before Delcassé began his conversations with Phya Sri Sahadeb, Robert de Caix, a leading member of the *Comité de l'Asie francaise,* wrote:

> Our policy must be to work ceaselessly to open the eyes of the English to the profound solidarity of the interests of the two countries in Siam. It is a matter for them, as for us, of preventing the third robber—Japan, a Far Eastern nation, excited by Pan-Asiatic ideas, the least feared today because she is their ally, but the most formidable—from slipping through the fissure left open by the rivalry of the two western powers. Possessing neighboring empires, they would have everything to gain by coming to an understanding to close the door by a mutual agreement, we will say even a sincere and loyal *condominium* over the valley of the Menam.

Not until he felt reasonably assured of a favorable outcome did Lansdowne consent to take up the Siamese question. On March 4, 1903, he apprised Cambon of his arrangement for Kelantan and Trengganu. On July 2 Etienne, a parliamentary spokesman for the French colonial group, acting as a herald of the Loubet party's visit to England, conversed informally and frankly with the British foreign secretary. He affirmed that France no longer desired to annex Siam, that the conduct of both powers had demonstrated their acceptance of the principle of spheres of influence, and that there no longer existed any cause for disagreement between them. Five days later Lansdowne talked with Delcassé and affirmed that Great Britain had no desire to obstruct French railway development in the Mekong valley. Both men were really convinced of the practicality and desirability of an understanding. Lord Cromer of Egypt considered that Great Britain could very easily accept Delcassé's proposals regarding Siam.

On July 27 Delcassé prepared a rough draft for a general entente. He pointed out that the British sphere of influence in Siam, although smaller than France's zone, would be far more valuable because of its great resources and its strategic position. Not until October 1 was Lansdowne ready with a lengthy "unofficial" statement of Great Britain's views, previously agreed upon by the cabinet. In this formidable document, the stipulations suggested by Delcassé regarding Siam were elaborated, evidencing complete agreement on the question. On November 20 Lansdowne told Cambon that no further discussion on Siam was required.

The three paragraphs devoted to Siam in the declaration of April 8, 1904, were identical with Delcassé's draft submitted to Lansdowne on March 21, 1904, and based essentially on the latter's statement of October 1, 1903. Articles I and II of the 1896 agreement, defining the neutralized area of Siam and affirming the intention of the signatories to uphold her independence against a third power, were confirmed. All Siamese territories east and southeast of the Menam basin were recognized as lying within France's sphere of influence; all territories to the west of this basin and of the Gulf of Siam, including the Malay Peninsula, were to constitute Great Britain's sphere. Within these regions the dominating powers were to enjoy complete liberty of action.

Although the customary disavowal of any intention to annex territory was included, a fact stressed by Lord Lansdowne for publicity purposes, the declaration really proclaimed the partition of Siam and the determination of the powers to do as they pleased with the Menam basin. The Menam basin, as defined in this agreement, did not include all the neutralized area specified in the declaration of 1896; important sections in northern Siam were excluded. A contemporary critic has accurately, if somewhat flippantly, characterized as follows the plight of Siam as set forth in the *Entente Cordiale*:

> England says to France, "You strip him on one side, I will strip him on the other. As to the middle, we may leave that alone for the present."

CONCLUSION

The *Entente Cordiale* settled the Siamese question in its late nineteenth-century form. In British and French circles, the settlement was generally welcomed. One French deputy, however, indulged in the startling prediction that France inevitably would lose her influence in Indo-China through a revolt of the natives, the expansion of China, or the conquest by Japan.

Several years elapsed before the territorial fruits were gathered. By the treaty of March 23, 1907, Siam ceded to France the valuable provinces of Angkor and Battambang. Great Britain's exactions were more severe. By the treaty of March 10, 1909, she acquired the rich states of Kelantan, Trengganu, Kedah, and Perlis, and other concessions in Siamese Malaya.

In the *Entente Cordiale,* as in earlier phases of Anglo-French rivalry, Great Britain gained the most advantages. France proved unable even to develop her sphere of influence in the Mekong valley. The British, however, not only annexed desirable areas and acquired an unshakable hold on western Siam, including the whole Malay Peninsula, but they continued to dominate Siam proper. The Siamese were de-

termined, though helpless. Whether they would be able to keep what remained of their territories, only the future could tell.

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FLORIDA CITRUS MARKETING TRENDS

Frederick K. Hardy
Florida Southern College

Gigantic and lusty, the citrus industry is exceeded only by tourists as a source of income for Florida. Florida's gross income from citrus fruit varies from forty to seventy millions of dollars a year, amounting to about as much as the income from all other agricultural produce combined. Yet the citrus industry, as an industry, is barely out of its infancy; it is yet far from full grown. Industries rise from household and family production for purely personal and private needs, and citrus fruit was grown in Florida in that way before the American Revolution. It was not until after the war between the states, however, that considerable commercial volume developed, which has risen more or less regularly to a pre-freeze U. S. Department of Agriculture crop estimate last year of 53,000,000 boxes, of which 81% was actually harvested.[1]

VOLUME OF CITRUS PRODUCTION

The volume of citrus production seems likely to grow larger and larger. Citrus is not an annually planted crop; it grows on trees, which require five or ten years to come into production, and which bear more and more fruit as they grow larger. The effect on production of one unprofitable season, therefore, would not be reflected in a reduction of supply next year or in five years or ten years, if indeed, ever. If tree plantings were to stop altogether, the upward trend in the supply of fruit would be unchanged for five years and only slightly diminished for five more years. Even then, the supply would continue to increase, with only the rate of increase perhaps moderated. Tangerines offer an example of this phenomenon in actual practice. Plantings of citrus as a whole, however, have not stopped—far from it. Hundreds of acres have been planted in the past few years.[2]

In fact, plantings continue regardless of profit. Northern oldsters retire to a Florida orange grove in much the same romantic innocence that they might sail to the South Sea Isles. There ought to be a law to protect such senior citizen babes in the wood from the citrus slickers;

[1]Florida Citrus Producers Trade Association, *Special Bulletin,* June 19, 1940, p. 3.

[2]Growers Administrative Committee, *Annual Report,* 1939-40, p. 3.

and conversely to protect the citrus market from their production regardless of cost.[3]

Florida oldsters, finding that they get for their citrus a declining percentage of a declining price, increase their production to make up for income reduction caused by the decline, which causes further decline and so on and so on and so on—a vicious spiral of deflation.

The trend of citrus production in Florida, then, is upwards; and the future production estimates are also upwards, even to the point of apprehension of ruin, or of riches.

Without development of adequate markets, the prospective flood of citrus production means ruin for the price structure and the Florida growers—black ruin.

With development of markets to keep pace with or surpass expected production increases, the citrus grower's future can be as golden as a grapefruit.

This, to the economist, looks like the development of large scale production, which is limited only by the extent of the market.

In order to permit full growth to an industry, the extent of the market must cover, first, the nation and the world; second, the entire year's market demand; and third, prices must be low enough to serve the two-thirds of America's families with incomes below $1500 a year, in the aggregate, the mightiest of all mass markets.

PRICES OF CITRUS FRUIT

If mass consumption is to match mass production of citrus fruit, consumer prices must come down, or the national income must be raised. Since the national income cannot be controlled upwards by the citrus growers, it follows that citrus costs of production must be lowered more and faster than the consumer price if grower profit is to survive, and that is being done by some leading growers. The lowest cost that I have heard of is sixteen cents to grow a box of grapefruit.

The possibilities of economies in large scale production must more than offset the increase in cost of wider marketing, and the decline in consumer price if growers' profit is to increase and growth continue.

As the volume of citrus production rises, the price of citrus fruit to the consumer is coming down, and since the tree to auction costs are relatively stable, the decline comes out of the return to the growers.[4]

[3]Statement of Marvin H. Walker, Florida Citrus Producers Trade Association, personal interview.

[4]U. S. Department of Agriculture, Bureau of Agricultural Economics, "Orange Production & Farm Price," and "Grapefruit Production & Farm Price." Graphs from *The Citrus Industry,* etc., A. R. Mead, (N. Y. A. Publication, 1940), p. 100.

TABLE 1

Preliminary estimates of returns received by citrus growers all states, for interstate commercial shipments, 1936-40[5]

	1936-37	'37-'38	'38-39	'39-40[6]
ORANGES				
Florida				
Auction Average (10 markets)	$3.21	$2.24	$2.09	$2.34
Tree to Auction Costs per box	1.60	1.60	1.60	1.60-1.65[7]
Net to Grower per box	1.61	.64	.49	.43-1.26[8]
California-Arizona				
Auction Average (10 markets)	$4.07	$3.34	$2.85	$2.98
Tree to Auction Costs per box	1.80	1.80	1.80	1.80
Net to Grower per box	2.27	1.54	1.05	1.18
GRAPEFRUIT				
Florida				
Auction Average (10 markets)	$2.23	$2.16	$1.71	$2.14
Tree to Auction Costs per box	1.50	1.50	1.50	1.50
Net to Grower per box	.73	.66	.21	.64
Texas				
Auction Average (10 markets)	$2.10	$2.08	$1.87	$2.03
Tree to Auction Costs per box	1.60	1.60	1.60	1.60
Net to Grower per box	.50	.48	.27	.43
TANGERINES				
Florida				
Auction Average (10 markets) (Std. Bx.)	$2.21	$2.48	$2.00	$2.74
Tree to Auction Costs per box	1.75	1.75	1.75	1.75
Net to Grower per box	.46	.73	.25	.99

[5]Table adapted from Florida Citrus Producers Trade Association, *Bulletin*, June 19, 1940, p. 5.

[6]Season 1939-40 figures cover shipments to June 8 only.

[7]Pre-freeze cost $1.60 per box; post freeze $1.65.

[8]Pre-freeze return $.43; post-freeze $1.26; season $.72½.

High cost producers cannot regard this prospect of falling prices with equanimity; but progressive low cost producers see a multiplied prospect of profit in the multiplied extent of the market at lower prices. Even at a narrower margin for profit these trends are not unprofitable nor unwelcome to the efficient leaders in lowering production costs in Florida.

Low cost vitamin C is, of course, in the interest of the public generally, so that even the children of the poor may grow up strong, tall and healthy; and research under the Florida Citrus Commission and the Kudner Advertising Agency has discovered that even at present prices, grapefruit juice is cheaper than any other source of anti-scorbutic acid except raw cabbage.

RESTRICTION OF SUPPLY OF CITRUS FRUIT TO MAINTAIN HIGH PRICES

The great numerical majority of small high cost growers in Florida, however, fear low prices, and cannot survive them. Knowing a bare minimum about economics,—the law of supply and demand, they have promoted politically a restriction of supply to raise the price. One after another, laws have been passed to restrict supply, turn back the clock, and repeal economic law, and they failed. The present restriction calls for the prohibition of shipment from the State of certain grades of citrus under a U. S. federal marketing agreement. For example, of the expected 30,000,000 boxes of Florida oranges for the 1940-41 season, only an estimated 23,775,000 boxes will be permitted to move to market.[9]

Of the expected 22,000,000 boxes of Florida grapefruit, only 10,000,000 will be permitted to move to markets in fresh form. The United States is doing this, regardless of our constitutional guarantee of free trade between the states, and regardless of rights to healthful food at the lowest possible price of the one third of our population, ill fed, intending to protect thereby about fifteen thousand small, old style, high cost Florida growers. Such a policy could not survive in a democracy, if it were generally understood.

In the 1938-39 season, 25,759,000 boxes were shipped, which resulted in the lowest recorded price; so this season, it is planned to prohibit enough grades from shipment to allow only 23,775,000 boxes to move in the hope of a better price.

Last January's freeze affected fifty-five per cent of the oranges on the trees at that time, and raised the growers' price 300%—a terrible catastrophe or a gift of God depending upon whether your crop froze or survived. Similar hardship on individual growers is worked by the shipment restrictions.

Restriction of supply works in the short run to raise price; but in the long run it is sheer suicide. Other citrus areas benefit from our restriction and other fruits and even other goods competing for the consumer's dollar. In the long run, no production restriction plan has ever succeeded, though many have been tried.

The effects of this restriction may be seen in the declining share of the crop sold in auction markets.[10]

[9] *Report of the Growers Administrative Committee and the Shippers Advisory Committee,* Oct. 16, 1940.

[10] G. E. Copeland, "Protecting the Citrus Markets," *The Citrus Industry,* May, 1940, p. 6.

1934-35	45%
1935-36	43%
1936-37	41%
1937-38	40%
1938-39	38%

LOW PRICE PROMOTION METHODS

A far sounder long term policy, alternative to the restriction of supply, is the creation and expansion of demand. Creation of multiplied demand at a low price is far more difficult than restriction of supply; but prospects for profits are infinitely greater. Consider Henry Ford's fortune or the Woolworth fortune or the Hartford's income from A & P stores and then try to remember any comparable present fortunes based on restriction; there are none.

Certain trends are evident in this direction already. Sunkist directors have just voted an increase of two cents per package box on lemons and on navel oranges for the 1940-41 season, which brings the lemon assessment to twelve cents a box, but that is in California.[11]

A small sample beginning in advertising Florida citrus is the pathetic penny for advertising oranges, which we use to compete with California's seven cents a box. The trend here is obviously up—from nothing to one penny. It should be at least two or three per cent of the consumer's price, to compete with other products for the consumer's dollar. We can compete if we will, for the Florida tangerine campaign of last year was one of the finest and most successful that I have ever seen.

INCREASE IN TRUCKING AND JOBBING COMBINED

Shipments of Florida citrus fruits by truck represent a romantic and fascinating new growth. The gypsy truck is to the highways what the tramp steamer is to the seven seas, an independent contract carrier who may carry anything anywhere, anytime. Frequently he owns his truck, or is making payments on it, and lives in it more than anywhere else in particular. Frequently, he owns his cargo, operating as a combination of merchant and transport, like Sinbad the Sailor. Since he combines two stages of distribution and eliminates at least two handlings of the fruit, he can sell Florida citrus fruit as far north as the Canadian border and as far west as Oklahoma more cheaply than

[11] *The Citrus Grower,* Sept. 27, 1940, p. 3.

others can. The share of total shipments going by truck has therefore increased as follows:

1936-37	14.2%
1937-38	15.9%
1938-39	19.3%
1939-40	24.1%

The trucker is the gentleman of the highway, and a substantial citizen; but his truck is not always insulated. Fruit cannot be shipped frozen from Florida; but it may arrive in Milwaukee frozen.[12]

INCREASE IN CITRUS CANNING

The share of Florida citrus fruit to be canned shows a rising trend, which will accelerate as the flavor of canned juice and fruit improves, and as increasing production surpluses provide low cost fruit.

TABLE 2

PERCENTAGE OF FLORIDA AND TEXAS CITRUS CROPS CANNED, 1936-40[13]

	1936-37	1937-38	1938-39	1939-40
Florida Oranges Per cent	3.2%	5.1%	3.9%	15.1%
Florida Grapefruit Per cent	37.1%	41.4%	35.9%	55.5%
Texas Grapefruit Per cent	26.8%	43.3%	30.6%	49.0%

[13]Table adapted from Florida Citrus Producers Trade Association, *Bulletin,* June 19, 1940, p. 4.

Fruit, which cannot be shipped because our grading system is mostly concerned with the size and color of what goes in the garbage can, may be perfectly good or even superior for juicing and canning.

Frozen fruit, which cannot be shipped because it might spoil or dry out, is distinctly superior for juicing and canning, for the flavor is concentrated by the cold, and it can be bought by the canner very cheaply.

Canned fruit cures some of the most glaring defects in the marketing of Florida citrus fruits. It can be shipped all over the world without deteriorating and it can be sold throughout the year, even in the summer when Florida has no fresh oranges to ship.

[12]Florida Citrus Producers Trade Association, *Bulletin,* June 19, 1940, p. 3.

GRADING

Our grading system is almost amusing. California citrus fruit has a better external appearance than much Florida fruit, owing to circumstances beyond our control; but Florida citrus has usually about thirty per cent more juice and tastier juice; so we grade the husk. I am reminded of the countryman who reported of his first banana, that he didn't like it much, that it was mostly cob and the rest was tough and stringy. There is a movement which may take effect the year after this coming year to establish permissive grading of juice.

It is interesting to note parenthetically, that California shipments of fresh fruit are centrally controlled to continue throughout the year with little variation from month to month as market needs require. Florida jilts the fresh fruit market every spring, and then tries to woo it away from California again in December—a high cost and low efficiency inconstancy which permits California to dominate markets which would otherwise belong to Florida.

Trends are unmistakable, to summarize, upwards in the volume of citrus fruit production, downwards in price to the consumer and even more sharply downward in the price received by the grower; downwards in the share of fresh fruit moving at high prices to auctions; upwards in the share of shipments moving economically by truck; and upwards in the share of the crop going cheaply to canners.

What, then, of the future? These trends will continue; and there should also appear something more, something new—trade promotion in the modern manner will replace dumping. Citrus fruit is no longer competing only with apples or other fruit. Citrus production and use has increased 25% while other fruits increased 5%. That competition is outstripped and that market is saturated. Orange juice is competing now with other soft drinks. It is healthier and tastier; but it is costlier, and it shouldn't be. Other soft drinks are better packaged, for display, for preservation, and for convenience; and other soft drinks are infinitely more advertised and better merchandised. Citrus fruit juices can be better packaged, advertised, and merchandised; and in time they will be better packaged, advertised, and merchandised.

A RE-EXAMINATION OF FREUDIAN SYMBOLISM

RAYMOND F. BELLAMY
Florida State College for Women

On September 23, 1939, a harassed, bewildered, old man, a refugee from Nazi persecution, died in London, England. Sigmund Freud, the center of the greatest controversy since the days of Charles Darwin, had come to the end. It is probable that Freud has affected the thinking of the world more than any man since Darwin. His work was of such a nature that he attracted a group of disciples who followed him, at least for a time, with fanatical devotion. With equal zeal, but with bitterness instead of devotion, another and larger group attacked him as an utterly false prophet. And, as is always the case, the great mass of laymen and scholars alike came to some snap judgment without much more information than the way to pronounce his name. A very few refused to be swept off of their feet in either direction but made a careful study of his system, evaluating his theories, rejecting what they considered unsound, and accepting the wheat out of the chaff. Among these the most outstanding was G. Stanley Hall, who not only read everything he could find which was written by and about Freud, but went back and read it a second time and in addition brought Freud and a few of his disciples to this country in 1909 for an institute at Clark University.

The modern world has little concept of how much its thinking differs from that of pre-Freudian days. Today psychologists typically announce that they reject Freudian concepts, almost in their entirety, but they accept an amazing number of them under other names without realizing that they do so.

One of the fundamental concepts of Freud's system was what he called "symbolism." He pointed out that when one dreamed of some innocent object, such as a hat or a tree, it symbolized something else, usually something with pointed sexual significance. This particular theory has been laughed to scorn, labelled as rank superstition or mysticism, and treated as a childish phantasy. But almost never today do we find anyone who fully comprehends the meaning of the Freudian symbol.

In attempting to arrive at the true significance of Freudian symbolism, we must realize first of all that Freud really had a little common sense. It is inconceivable that a man not confined in an institu-

tion for some kind of mental defectives should hold any such beliefs as so many think Freud did on this point. As is always the case, if a world renowned scholar makes some perfectly commonplace remark, it will be taken up, analysed, and made to have some deep underlying significance which was never intended.

Cases of this kind are legion. Perhaps the best known of all is Agassiz's well remembered statement that fish is a good brain food. The morning after he said this it was repeated as a newspaper headline. He spent much of the remainder of his life explaining that he did not mean that fish was any better brain food than beef or chicken or onions and potatoes, but he never was able to live it down. We still hear at frequent intervals that fish is a good brain food. Darwin said that there is in nature a struggle for existence, and some hundred thousand times since then he has been quoted as saying that man is always naturally at war with other men. Actually Darwin quite specifically insisted that man is naturally social, gregarious, and inclined to cooperate. Malthus used a strong figure of speech and said that population *tends* to increase in geometric ratio and food supply only in arithmetic ratio. Unless we rule completely out the possibility that Malthus had a modicum of common sense, we can not conclude that he meant this to be a statement of mathematical accuracy. Yet many people do make just such a conclusion and even neglect to include the word "tends" when they quote Malthus. Ricardo's "iron law of wages" is another case in point. We could find thousands of such instances if we tried. Even the most hard-boiled exacting physical scientist will occasionally lapse into everyday terminology and say that the sun has gone down and the stars have come out.

Let us remember then that Freud had a little common sense and not try to read some weird mystical meaning into his statements. He used the term "symbolism" to mean nothing more nor less than the fact that one thing becomes associated in our minds with another and hence stands for it. To be sure, he usually discusses his symbolism in connection with dreams, but he points out the fact that the same rules work for ordinary day time experiences. This point is generally missed by superficial students of Freud but becomes thoroughly familiar after one has lived with his theories for years and gotten what might be called the feel of them. Freud's disciples do not always show this as clearly as Freud himself. But even Stekel, who was considered to be about the most extreme of all Freudians, points out that wholly different sets of symbols obtain for people in different walks of life and that in all cases, one gets his symbols from his associations.

When we realize the true meaning of the Freudian symbol, then we recognize the fact that we have accepted it all along. Our lives are a perfect welter of symbols. Some symbols, as Freud pointed out, are for all practical purposes universal. The flag symbolizes the country. The swastika today symbolizes Hitler and his rule to practically the entire world. With almost equal universality, the dove symbolizes peace, the cross Christianity, a white lily purity, and a donkey the Democratic Party. On the other hand, there are individualized symbols. To the writer, the smell of sage brings a quick nostalgic memory of damp mornings in the Rocky Mountains where blue columbines bloomed, the cut-throat trout rose viciously to the fly, and black-tailed deer hid in the quaking asps. To others the smell of sage may symbolize roast turkey dressing on Thanksgiving. To one, a blue bead may symbolize a little brother who died years ago. To another, it may symbolize a sweetheart whom one expects to see at the weekend.

Sometimes these symbols are so highly colored by emotional associations that they become pathological. The finest college athlete I ever knew, a young man who apparently did not know what fear meant, ran and jumped into bed and covered his head when a harmless little bird got into the room. When he was a child an old gander had beaten him soundly and ever since anything which had feathers was a symbol of peril and destruction to him. Church bells may bring back the memory of a mother's funeral and become so hateful that one can not go to church. In one of Freud's earliest cases, a young girl could drink no water and had to substitute juicy fruits. Analysis showed that a glass of water symbolized a little dog which she had seen drinking from a glass and consequently caused nausea. Almost unbelievably far-fetched symbolism of this kind may be built up.

It should be remembered that Freud was a physician. He worked with sick neurotic people. His technique was developed for the purpose of curing or helping these people. Hence it is natural that the bulk of his writing about symbols should be concerned with such pathological and abnormal examples. But the very heart of his theory was that the same sort of thing went on constantly in a perfectly natural, normal, and not at all surprising way for each one of us.

Another feature of Freud's symbols is that they so frequently had a sexual significance. In a dream, one would substitute something far removed for a sexual object or experience. This, of course, is nothing more than what we do everyday. A group of men may discuss sexual matters very freely, but in a mixed audience they will substitute other terms. Some years ago, this was more pronounced.

At that time, even the word "leg" was not used in polite society. When absolutely necessary to refer to this useful and ornamental portion of the body it was called a "limb." Just some four or five years ago, the management of WSB—and presumably other broadcasting stations —absolutely refused to allow lecturers to use the terms syphilis and gonorrhea over the air. Other terms had to be substituted.

If we analyse our daily practices a bit we can easily see that we use symbols regularly and constantly in referring to sexual matters. Dreams, of course, differ from waking life in many ways. But fundamentally the symbolism employed in dreams is no different from that used when one friend turns to another and says, "Hello, old mullet-head, how you feeling? Are all your cylinders hitting today?"

To read a paper on Freudian psychology and not give a dream analysis would be rank heresy. The writer could use any one of two hundred and ten of his own dreams which have been studied and analysed, but instead we will use a dream of some one else. As it so happens I received a letter from an old university classmate some two years ago which contained a description of a suitable dream. He had been impressed by this dream and remembering our mutual interest, he wrote me about it. He was very frank in his discussion. Those who have studied Freudian psychology together are quite apt to be frank—at least with each other.

This friend, now well along in middle life, is a teacher in one of the Western States. The institution with which he is connected recently put on an expansion program and moved its plant to a suburban section. As a result of this, he found it necessary to move his residence. This was a cause of considerable perturbation to him and he worried quite a bit over the impending move. It was during this period of emotional tension that he had the following dream.

He dreamed that he had given up his position and accepted one, apparently not nearly so good in St. Louis. He realized he had made a mistake and was miserable about it, but it was too late to change. He had moved to St. Louis and gone to a boarding house with his wife and baby. His wife was utterly worn out and half sick, the baby fretful and not well, and he had only a few paper dollars in his wallet. To add to his consternation, the landlady told him she could not take children and he would have to find some other place to go. She did, however, grant him the privilege of staying a few days until he could find some other location. Making his wife and baby as comfortable as possible, he went out to get some few groceries and medicines. On his return, the wife and baby were both worse. But to add to the dismal picture his wife had ordered a whole cord of wood and it was all stacked up in their room. Shocked by the appearance of the room and the cost of the wood, he went out again this time to hunt for another apartment. He was directed from one place to another and finally entered a large building which he took to be an apartment house. But once inside he discovered a number of disquieting things. It was not an apartment house but a store building; it was dark inside, and he could not

find his way out. Moreover a policeman entered and thinking him a burglar, carted him off to jail. He was a total stranger in that city and the case looked bad against him. As a final stroke, he realized he had neglected to get the address of the rooming house where he had left his wife and baby and had no way of communicating with them. He realized they were without money, were sick and helpless, strangers in St. Louis, and he had no way of helping them in the least. Mercifully at this point he woke up.

Of course, this dream had been subjected to what Freud calls secondary elaboration or considerable modification after he awoke, but we are giving it as it was told, since that is what is important for our purpose.

This dream is saturated with symbolism. It symbolized many immediate things in his experience and also many experiences of his earlier life. This is strictly in accord with the Freudian insistence that the casual influences in a dream can be traced farther and farther back until they reach childhood. In other words, a dream, just like any other subjective experience we may have, is the product of all the experiences of one's life.

Of course, the primary significance of the dream was that it symbolized the move just ahead of him which he dreaded so much. But more deeply it symbolized the feeling of frustration which he had always experienced and which just at that time was unusually acute.

Each element of the dream was a symbolic reproduction of some experience he had actually had. Some of them were almost duplicates. Once on moving to a Texas school his family had encountered an unexpected cold snap on their arrival. Also his wife and baby were sick at that time. His difficulty in finding a suitable apartment was really an old story, as was his rather desperate economic condition. Through mistaken identity he had once been in considerable danger of arrest on a rather serious charge. While on a geological collecting trip in the Black Hills of Dakota he had once become lost for a short time. This did not prove to be serious, but for a time it had caused him great distress, because he knew his family would be worrying greatly and he had no way of assuring them that he was all right. These are true examples of Freudian symbolism, though they are hardly the type usually quoted. They are merely the more plainly evident forms.

More subtle symbolism can also be found in this dream. The cord of wood in their room symbolized secret and hidden feelings of shame that their home had never been as attractive as it might have been. This, he explained was not due to any slovenliness on the part of his wife, but was the result of her delicate health and his own financial inability to furnish sufficient domestic help and labor saving devices. During his worries over the change of location, he had naturally thought back over the moves they had made in earlier life. He re-

membered various times when he had been embarrassed by having visitors drop in and find a badly disordered house. Hence his dream of the cord of wood in the bedroom. This wood—or rather his wife's act of purchasing it—had still further symbolic meaning. Somewhat habitually he had been caused considerable trouble by unwise and somewhat extravagant purchases which his wife made. Hence in his dream she ordered a whole cord of wood and they were to stay there only a few days.

Another interesting bit of symbolism was his getting lost in the dark building and his subsequent arrest. In writing about his experiences he said, "When I discovered I would have to move, I felt as if I were trapped, and did not know which way to turn." The symbolism here is clear.

It is probable that there were still more subtle examples of symbolism in this dream, but he did not mention them. There are some things which even hardened students of Freudian psychology will not disclose to each other. But the examples given are sufficient.

There was a minimum of repression shown in this dream. This is typical of the dreams and even waking thoughts of students of Freud. They arrive at the place where they can not cover up their unconventional, ungentlemanly, or selfish wishes from their own understanding eyes. In plainer language, they can no longer kid themselves. Moreover, they come to realize that such wishes are really natural and universal and there is no reason why they should be ashamed of them. Hence the element of repression is all but absent.

There is also absent from this dream any elements which are overtly sexual. We should hardly expect a man closely approaching sixty who was worried half to death about finding a decent place to live and about accompanying financial difficulties to have much violently sexual coloring to his dreams. But in the true Freudian sense, this was a real sexual dream for all that. It must be remembered that the German word, especially as it was used by Freud, which we have translated "sex" has a meaning which differs widely from that which we give it. It is really synonymous with "love". Freud includes in the concept not only sexual love, but the affection between parents and children, brothers and sisters. And the very core of this dream was a deep concern for his wife and child.

It will be seen from the description given that the Freudian symbol is not something weird, something fantastic, magical, or mystic. It is a perfectly natural way in which we associate two objects or ideas in such a fashion that one stands for the other—as baked beans remind us of Boston, blue grass of Kentucky and Jello of Jack Benny.

Of course more startling and extreme examples of symbolism could easily be found. They are encountered every day, some of them pronouncedly sexual and some originating in other fields. One of the most interesting I have ever encountered lacked the sexual element entirely. A young woman, under the stress of undue emotional pressure had made a solemn vow to devote her life to foreign missionary service. Some years later she realized that she did not want to go, that the idea was horrifying to her. But she fought against what she considered the temptation to stay at home. In discussing the matter, she always referred to any possible decision to stay at home as a *fall* or as *falling* from a high purpose. Repeatedly she would awake screaming and would explain that she had dreamed she was *falling*. It is exceedingly probable that her dream of a *fall* symbolized her unacknowledged desire to *fall* from her pledge. Freud found many quite similar cases.

A very legitimate criticism of Freudian psychology is that we *assume* these elements of dreams are symbols but can not prove it. This fact was noted by Morton Prince who said that the situation was similar to the first phase of discovering the germ which causes some disease. First, he said, we learn that the germ is present whenever one has the disease. But this alone does not constitute proof. Before a final conclusion can be drawn, the disease must be produced by implanting the suspected germ. Dr. Prince attempted this type of thing with Freudian symbols. He told one of his patients under hypnosis that she would dream she was a great psychologist, but he did not tell her what form the dream would take. That night she dreamed that she saw many people working on a great temple which was in process of construction. Some of them were building it up and others were tearing it down, so that it was going up very slowly. And William James said to her, "Some of these have done much to erect this temple, but you have done more than all the rest." Prince felt justified in concluding that this was a clear case of symbolism, induced by his suggestion.

We do not have to go to dreams to get far-fetched symbols. We meet such exaggerated forms in waking life every day that we would be inclined to reject them if they were in dreams. My son, whose name happened to be R. Edward, announced when he was a young child, "I'm a red-headed woodpecker." When asked why, he said, "Well, my name begins with R, and my name's Ed—that makes Red—I'm a red-headed woodpecker." Since this happened in waking life it can not be disputed. But if one dreamed of a woodpecker and by process of analysis and association decided it symbolized such a name, there are many who would pooh-hoo it.

We do not think it strange when a bragging man says, "I tell you, I'm a regular horse." Therefore we should not be surprised if such symbolism appears in a dream. Similarly, we may use such symbolism as a snake in the grass, a faithful old watchdog, a skunk, a greedy pig, a crowing rooster, an unfortunate goat, a sly fox, a strong ox, a cold fish, a gentle lamb, or even a white elephant. And waking or dreaming we may employ such symbols as a tall pine, a strong oak, a weeping willow, a graceful elm, a clinging vine—perhaps even poison ivy—bright-faced daisies, modest violets, retiring ferns, aristocratic orchids, common dandelions, obnoxious thistles, beautiful roses, peaches and cream, or sour lemons. We may call our friends or enemies any of those names.

We speak in terms of symbols, we think in terms of symbols and we dream in terms of symbols. Reduced to its elements that is all Freud meant. The fact that he gave pathological and extreme cases is what we should normally expect. There was no occasion for him to keep talking about the ordinary cases. What he was attacking was the pathological, the diseased, the warped, twisted, abnormal and unusual.

Of course wherever there are great billows of smoke there must be some small amount of fire. It is quite true that Freud's disciples did make some wild statements. Coriat, for example, carried the idea of symbolism to ridiculous extremes. And, no doubt, Freud himself made many statements which were overdrawn. No man yet has had a perfect record.

The object of this paper is not to advance the theory that Freud was always right, even about the one concept of symbolism. The attempt has been to show that when properly understood, Freudian symbolism is not the wild phantasy of an erratic mystic, but is really something quite tame, quite everyday and quite in line with common sense and good psychology.

BIBLIOGRAPHICAL NOTE

Any attempt to give bibliographic references for the statements in this paper would involve a mass of references so extensive that it could not be handled. Any one of the general statements made could be referred to at least a score of sources. Moreover many points were secured from oral rendition of papers and talks, as well as from published reports—as for example, Morton Prince's experiment. However, the *American Journal of Sociology* for November, 1939, is devoted to a discussion of Freudian concepts and gives a good review of the present day attitude.

SHOULD BANKS BE PERMITTED TO FAIL?

Frank W. Tuttle
University of Florida

There is a distinction between a bank failing and a bank closing. A bank fails when its demand deposits are no longer available to the depositors. A bank closes when it ceases to function as such. A bank may close when it merges with another bank, but the activities are carried on continuously and the depositors are not deprived of the use of their deposits.

One of the characteristics of the development of commercial banking in the United States has been the recurrence of periods of bank failures. Independent unit banking has long been championed, and still is, by many bankers and others, as that system best suited to the industrial and agricultural development of a democracy. Individual initiative and competition have brought about a rapid development of banking in the United States in the financing of industries organized for the purpose of exploiting land and other natural resources, including innocent investors.

The post World War period was one of inflation, industrial expansion, stock market speculation and agricultural depression. A false feeling of economic security was fostered by a self induced credit financed expansion of foreign markets, together with the philosophy of our political leaders who preached the doctrine of perpetually rising prices accompanied by a condition of perpetual prosperity. Installment buying was almost universal and persons were living far beyond their money incomes. Banks were failing in increasingly large numbers and unemployment was prevalent, although few persons heeded these danger signals. The stock market crash occurred in October, 1929, and in 1932 and 1933 the banking system utterly collapsed, culminating in the banking holiday on March 4, 1933, at the inception of the Roosevelt administration. Deposits shrank thirty per cent and thousands of depositors were deprived of all or part of their purchasing power. A deposit insurance plan, more properly one of guaranteeing deposits, was incorporated permanently into the Bank Act of 1935, since which time few banks have failed, but in those instances in which insured banks have been forced to close their doors, the Federal Deposit Insurance Corporation has functioned to make the deposits available to the depositors only after a delay and interruption of service amounting to several months in many cases.

The Federal Reserve Banks have emphasized liquidity of assets in their relationships with member banks. The Federal Deposit Insurance Corporation emphasizes solvency in its examination of the books of insured banks. This difference in emphasis is really one of point of view and is justifiable under the existing set-up.

In spite of several and sundry suggestions that have been proposed to strengthen the banking system, none of them seem to recognize that in size there is strength and that competition among banks may be a source of weakness which may lead to the failure of a few banks or even of the entire system as occured in 1933.

Is there any more reason why a bank should be permitted to fail than that a public utility should be permitted to close down or to refuse to render service to a customer? Is an institution that furnishes the principal circulating medium of the country in the form of bank notes and bank deposits of any less importance than one that furnishes water, light or transportation?

It is true that the principal reason for not permitting a public utility to close is that it renders a monopoly service to the members of a given community. Denied the services of a public utility the entire community suffers the loss of the service rendered by it. Some residences may not be wired for electricity or piped for water or gas, yet their occupants derive a benefit from these utilities and they would suffer from the lack of them. Some persons may not have individual bank deposits, but they suffer along with those who do have them when banks fail. At present if a bank fails, the entire community may not be without the services of a bank. Competition has decreed that, even in many small towns, there be two or more banks in operation the year round when one bank could handle all of the business adequately and probably more efficiently. Even so, since the banks have been permitted to engage in deposit banking maintaining fractional reserves, they should not be permitted to fail unless their depositors are protected in full and at once. It is true that when one bank fails its depositors may open new accounts in another bank, but in so doing the purchasing power represented by the demand deposits of the failed bank is not released. This purchasing power is not available to the depositors until final settlement has been effected. Not only do the depositors suffer from the loss of their purchasing power but others who do not have any direct contacts with the closed bank are sometimes vitally affected. Members of society are so interdependent, the one upon the other, that a breakdown in the credit system has far-reaching economic and social effects. It is this fact that gives justification to this paper.

Banks are required by law to open for business every legal business day and to remain open throughout the whole period of the day until closing time, notice of which is always publicly displayed.

While banks have the privilege of selecting their depositors, they have no more control over who receives their depositors' checks in the course of business than they have over the selection of the holders of their notes. Holders of bank notes and of bank checks are both creditors of a bank. The fact that the holder of a check may have recourse to the person whose name appears as an endorser, or to the maker, is of little importance in this connection since their ability to pay when their banks are closed is impaired.

Obviously it was the intention of the framers of the Constitution to provide a stable currency that would always circulate at par. Since a large portion of the circulating medium is in the form of bank deposits, why not give official and legal recognition of this fact and provide for a more stable volume of deposits, at least as far as bank causation is concerned?

The United States Government is far more stable and permanent than is the life of any individual or corporation. It is interested in social conditions as they affect the welfare and well being of its citizens. Banks fail because they do not have sufficient cash to meet the demands of their depositors, even though they have assets that have value at their maturity but are not liquid. Why not let the Government meet this short run problem of insufficiency of cash as long as the banks have securities that have adequate maturity values?

At the present time, 1940, it is extremely doubtful if gold, as such, will ever circulate actively again as money. It is much more efficient when serving as a basis of credit. People are not inconvenienced by the lack of gold in circulation, and they have come to prefer the use of paper money and deposit currency as long as they are "as good as gold," that is, as long as they have the purchasing power of gold. This being the case, let Congress provide for a Board of Monetary Management which shall be entirely free and apart from any political or governmental organization and which shall have the sole right to issue paper money. When a bank is about to fail, let it appeal to this Board which shall immediately take charge of the bank and determine the maturity values of the assets in the bank's investment portfolio. On the basis of these maturity values the Board will issue notes to the bank for use in meeting the claims of the depositors, who by this means will have constant and continuous use of their purchasing power. These notes will have full legal tender privileges and will be free-

ly exchangeable for all other kinds of money at all times. These provisions should insure circulation of these notes at par.

Under present conditions there would be no point in providing for the redemption of these notes, as none of our monies are readily redeemable at the present time. Should the time ever come when our currencies are redeemable on demand in gold, it is doubtful if these notes would have to be given that privilege in order for them to circulate at par. There would never be a very large volume of these notes outstanding at any one time in proportion to the total volume of currency and they would be in constant process of retirement by the Board.

As the assets of the banks in the possession of the Board mature, notes that it has issued will be withdrawn from circulation, thus preventing monetary inflation.

Should the United States return to a free gold coin standard these notes should circulate at par as long as they have full legal tender privileges and are exchangeable for all other monies. However, gold redemption may be provided for in one of two ways.

Congress may appropriate a portion of the gold hoard now held at Fort Knox as a redemption fund to be held by the Treasury Department. The Treasury would redeem all notes turned in to it for that purpose and would hold them until retired by the Board of Monetary Management.

An alternative plan to provide for the redemption of these notes would be for the Board to sell gold bonds to establish a redemption fund to be used solely for the purpose of redeeming United States notes issued to depositors of failed banks. The interest on these bonds would be part of the operating expenses of the Board and would be appropriated by Congress out of tax receipts. Once established this fund would be perpetuated out of the receipts of the assets of the Board as they mature.

Even in case of fraud or embezzlement of funds, the Board will assume control of the assets of a bank since it is representative of the Government and the people as a whole, and is better able to withstand losses than are the unfortunate depositors who are entirely innocent of any wrongdoing, but who are made to suffer for the wrongdoings of those in whom they had put their trust. Sentencing an embezzler to prison may serve as a deterrent to others in the same or similar position but it does not restore purchasing power to those who have lost, nor does it instill confidence in the system in any person.

In order for the Board of Monetary Management to function to protect the depositors of all banks, the Federal Reserve System will

have to enlarge upon the scope of its activities to include all of the commercial banks, State and National. In effecting the transition from the present system to the new one, all State banks in operation at the time would be given Federal charters provided they could meet the requirements of the Federal banking laws in effect at the time. No attempt would be made at this time to reduce the number of banks or to consolidate them, except as may be necessary to prevent some State banks from closing because of their inability to meet the new conditions imposed upon them. Should the directors of State banks desire to cease to operate rather than to enter the new system, they would be permitted to do so provided their creditors could be paid in full and without delay.

The monetary functions of the Comptroller of the Currency would be assumed by the Board of Monetary Management, while the Board of Governors of the Federal Reserve System would absorb the banking functions of this dignitary. This action is in no way a reflection upon the manner in which the office of the Comptroller of the Currency has been or is being conducted. It is in recognition of the fact that there would be no *raison d'etre* of this division of the Treasury Department with the Board of Monetary Management assuming control over the issuance of money. Not only would the Board supervise the issuance of paper money; it would also administer the laws relative to the issuance of certificates, both gold and silver, greenbacks, subsidiary and token money.

The Board of Governors of the Federal Reserve System would exercise full supervisory powers over all member banks. It would be the principal bank examining body and would enforce the Federal banking laws.

The Federal Deposit Insurance Corporation would be liquidated since the new Board of Monetary Management would, in effect, guarantee bank deposits without limit without placing any financial burden upon the banks. The Board would call for occasional reports from the banks to enable it to influence the investment policies of the banks, looking toward maturity values of securities and collateral rather than to their liquidity.

Banks will continue to fail as long as they depend upon human judgments and valuations for their soundness. No person, banker or otherwise, is infallible in his estimates placed upon the value of wealth and of property rights. Society will shoulder the burden caused by the failure to judge correctly and no group of depositors will be deprived of its purchasing power. The monetary cost of administering the system will likewise be borne by society, the expenses involved

being cared for in the collection of taxes by the Federal Government rather than by assessments, regular or special, against the banks, themselves. This is justified on the grounds that bank currency is for the use of everyone and is not confined to any particular monied group. Once granted, bank deposits become almost as widely disseminated as do bank notes and Government money, and even those persons who do not handle them directly are affected by their use or by their disappearance.

The above outlined plan has several advantages, the principal one of which is its simplicity. It is easy for everybody to understand and it will result in the simplification of the machinery establshed to regulate money and currency, incidentally banking.

It will permit the use of fractional reserves in support of bank deposits and will make them more efficient and more adequate. There will be no new banking system to establish and become accustomed to as far as fundamentals are concerned.

There will be fewer regulatory bodies issuing orders to the banks and interpreting and enforcing Congressional measures. This will benefit the bankers who are sometimes badly confused by conflicting and contradictory orders emanating from a multiplicity of regulatory agencies.

The operation of the banks will be more uniform since all banks will be members of the Federal Reserve System and the several states will no longer have control over commercial banks.

The administration of the banks and the determination of the monetary policy of the United States will be removed from political domination. The Board of Monetary Management and the Board of Governors of the Federal Reserve System will still be able to cooperate with a particular administration in carrying out a policy for the good of the entire country, but the Treasury Department will no longer dominate the policies of these two boards for the benefit of the political party in power.

Fewer banks will fail and monetary panics resulting from the collapse of the banking system will be a thing of the past. There will still be fluctations in the volume of bank deposits, but these variations will be the result of factors lying outside the monetary and banking systems of the country.

Changes in the volume of money and currency will be in response to variations in the economic need for them and will be less of a causal factor in the periodicity of the business cycle. The dangers of monetary inflation or deflation initiated by the Treasury Department will be removed.

Some persons may raise the same objections to this plan that have been raised against deposit insurance or guarantee plans in the past. It is true that State deposit insurance or guarantee laws did not prevent banks from failing; in fact, they may have brought on some failures resulting from loose banking practices. The facts are very clear, however, that since the organization of the Federal Deposit Insurance Corporation bank failures have been reduced to a minimum. Under the plan proposed here, as banks close their doors new ones will be opened only after their organizers can establish good and sufficient reasons why additional banking facilities are required. In this manner, competition between banks will be reduced and as mergers and combinations are effected, banks will operate on a much larger scale than is now the case. The alternative to the successful operation of banks competitively under private ownership and management is complete Government control. If private capital is not attracted to the field of banking when the banks are under Government control, the alternatives are (1) Government ownership and operation of the banks; (2) abolition of deposit banking using fractional reserves; (3) branch banking, without reference to priority.

If the banks are owned and operated by the Government, all of the principles of a public utility will apply to the banks. If deposit banking using fractional reserves is done away with, deposit currency as we know it will no longer present any difficulties. If branch banking is permitted, it may solve many of the present difficulties in the realm of banking, at the same time presenting new ones in the guise of monopoly control of banking. In this case, public utility principles may have to be applied to banking. It seems clear that there should be larger banks and fewer of them and that competition between banks may be inherently unsound from the standpoint of sound banking principles.

It is assumed that when the Congress of the United States is ready to adopt a plan similar to this one that the proper legal framework will be provided.

Banks are so fundamentally important to the success of our economic system that all efforts should be made to remove the element of banking from the list of possible causes that may lead to a change in this system. Individual initiative and opportunity are retained and private property is not destroyed as much as under the present system of banking. If the present generation should be called upon to shoulder the burdens caused by another breakdown of the banking structure, the repercussions may be far more penetrating than they were following the collapse of 1933.

A RUST OF FLORIDA PINES CAUSED BY *CRONARTIUM QUERCUUM* (BERK.) MIYA.[1]

George F. Weber
University of Florida

INTRODUCTION

Probably from the dawn of knowledge and at least from the beginning of recorded accounts, as early as 1300 B. C., there exist references to the effects of rusts upon man's crop plants.

"Rubigo" and the festival dedicated to this rust god reputedly originated about 700 B. C. The importance of rusts can thus be readily imagined as they existed with the early Romans. Pliny (23-79 A. D.) calls rusts the greatest pest of the crops (*robigo maxima segetum pestis*). From the time of Pliny through the pompous days of Rome and its fall, followed by the dark ages and Renaissance period, no great change was manifest, or at least recorded regarding this early knowledge of the rusts, until about 1700 A. D. At this time the invention and partial perfection of the microscope brought about an extension of the field of vision and brought to the sight of man the individual spore forms produced by the rust fungi.

It was in 1660 that a law enforcing the eradication of the barberry was put into effect in Rouen, France. Five years later the first illustrations of the rust fungi were given to the public. A hundred years after the enforcement of the eradication law at Rouen, a similar law was passed in some of the New England States.

Persoon in 1794 is given credit for recognizing rusts as a separate group of fungi. Unger in 1833 saw, with the aid of the microscope, and illustrated in definite form the germination of a column of teliospores of a *Cronartium* sp., but further than this observation and record, he knew nothing of its parasitic role or its position as a plant, little of its relationship to the rust galls or how this portion may have fitted into the life cycle of this rust. The complete life history of a parasitic rust was first thoroughly investigated and published by De Bary in 1853. He not only observed the various stages of the complete life history, but reproduced them experimentally and illustrated them to the satisfaction of scientists at that time. Following this learned publication of De Bary the knowledge of rusts has continually developed. In 1854 Tulane reclassified the rusts and this reclassification has apparently been the primary basis for our present arrangement. He used

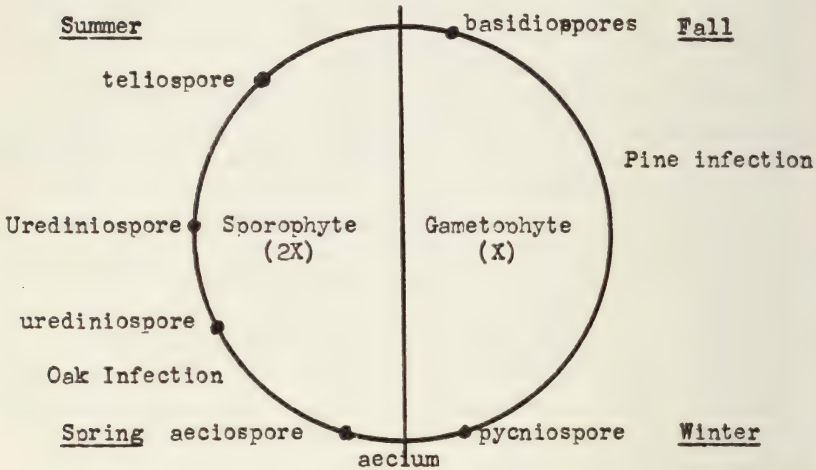
[1]The writer produces no evidence that *C. quercuum* (Berk.) Miya. is preferred to *C. fusiforme* H. & H. or *C. cerebrum* H. & L. as the correct binomial for the casual parasite.

the genus name *Cronartium* for the first time as it is known today. Since these original offerings concerning the rusts during the middle of the past century, studies of life histories have been begun, special technical knowledge has been acquired, and the origin, relationship and classification of rusts has been studied and tested. By means of experimental investigation of the physiology and morphology of rusts, and through studies of their dissemination, distribution, host range and specialization our present knowledge of the rusts has been placed on an exceedingly high plane.

The rust with which we are concerned at this time is confined entirely to the pines and the alternate host oaks which are of considerable economic importance and of wide distribution in Florida. The aecial stage of a dozen or more rusts is recognized as occurring on pines. *Cronartium sp.* attack several species of pines in Florida, developing in the bark of branches, twigs and trunks of trees of all ages. The fungous mycelium is perennial in these parts. Certain *Cronartium sp.* are capable of reinfecting pine trees through aeciospores, but none of these occur in Florida.

Rust fungi consist of vegetative and reproductive parts and are characterized as obligate parasites. Their spores are microscopic as individuals, of various sizes and shapes and yellowish brown en masse. Infections usually stimulate development of galls or proliferations of the host. The mycelium is separate and intercellular and haustoria are produced. One to several kinds of spores are usually produced on hosts and alternate hosts, hence the name heteroecious rusts.

The life cycle, beginning with the aecium, wherein cell fusion takes place inaugurating the sporophyte and 2X chromosome condition, indicated by the production of aeciospores, is found on one host, the pine. These aeciospores cause infection only on the oak wherein uredinia and unrediniospores are produced. These spores reinfect the same host and are thus capable of producing epidemics under favorable conditions. Telia develop and in the teliospore therein produced occurs fusion and reduction division. This concludes the sporophytic stage and the basidiospore formation marks the first development of the gametophyte. These spores cause infection and the pycnia, pycniospores and aecia are produced as a result. These developments close the gametophytic stage as cell fusion takes place and the aeciospores are produced. This life cycle of *Cronartium quercuum,* with possible wide variations according to local conditions, as it occurs in Florida is diagramatically illustrated as follows:



Cronartium quercuum is an obligate parasite unresponsive to artificial culture and is separated from *Coleosporium sp.,* the needle rust of pines by the fact that the aecia of *Colesporium sp.* are found on pine foliage and the aecia of *Cronartium quercuum* are found on the bark of trunk and branches of pine. *Cronartium sp.* also develop their urediniospores and teliospores on oak foilage whereas the *Coleosporium sp.* develop similar spore stages on various herbaceous plants. They are keyed as follows:

(1) Telia hairlike. Spores; 0, I. of pine stems. II, III, on oaks—*Cronartium.* (2) Telia cushion-like. Spores; 0; I, on pine needles. II, III, on herbs—*Coleosporium.*

Cronartium quercuum causing yellow pine blister rust in Florida is very common in the state wherever the host plants exist and its wide distribution is probably accounted for by the fact that it attacks four of the widely distributed species of pine, namely, loblolly, *Pinus taeda,* sand pine, *Pinus clausa,* slash, *Pinus palustris,* and longleaf, *Pinus australis.* The first named is most frequently attacked. It is possible that the other Florida pines may be attacked but we do not have available authentic records of its occuring on *Pinus caribaea, P. serotina* or *P. glabra.*

Outside of Florida rusts caused by this fungus or closely related species on at least five species of pines are plentiful and of considerable importance and have been designated by many local common names such as gall rust, fusiform rust, pine rust, pine gall and blister rust. Extensive cross inoculation experiments have been conducted by investigators who have found that most of the yellow pines become infected by one species of the rust. The fungus is heteroecious and this is of particular interest because the alternate hosts are about 25 species of oaks, *Quercus sp.* The oaks are widely distributed in Florida; in fact they are coexistent with the pines which clothe the state. The oaks are probably the most extensively used local ornamental and shade tree and include introduced as well as indigenous species. For the complete development of the rust disease it is necessary for the pines and oaks to grow in the same vicinity, at least within one-half mile of each other so that when the spores are produced on either host, they can be readily transmitted to and infect the alternate host. The fungus is a strict parasite and must pass all of its life time or complete its life cycle on living pine and oak trees. To do this it is necessary for the fungus: (a) to infect the pine, produce spores on the diseased areas on the pine, which (b) infect the oak, produce spores on the diseased areas on the oak, which (c) in turn infect the pine.

Thus spores produced on the pine infect the oak and spores produced on the oak infect the pine. Since the spores of Florida species of the rust fungus produced on the pine cannot reinfect the pine they will die if there are no oaks in the vicinity. The spores produced on the oak are of two kinds, one known as the summer spore, or urediniospore the other as the winter or teliospore. The urediniospore is produced after 10-14 days following infection by the spores from the pines. The sori that produce urediniospores are at first subepidermal, later become raised in hemispherical to oval shapes, rupturing the epidermal covering and freeing the spores. The urediniospores produced on the oak can reinfect only the oak and thus a close cycle of infection and spore production continues under favorable conditions and frequently produces epidemics in which all leaves on oak trees become heavily infected and often become noticeably yellow. Some may shed early but heavy premature shedding is not frequent. Telia sori which produce the winter spores or teliospores may appear on the oak leaves two or three weeks after the production of urediniospores has begun. The sori that produce most of the teliospores are subepidermal and produce a tube-like structure similar to coarse hair on the lower surface of leaves. These structures vary in diameter and length, possibly being constant to the oak species upon which they are produced. They may be so large and dense as to cover the entire leaf surface; then, in

contrast, one frequently needs some magnification to ascertain their presence. These spores are more resistant to unfavorable environmental conditions than the urediniospores and they are particularly characterized by the fact that they are not capable of reinfecting the oak host upon which they are produced but must infect the pine or perish.

The teliospores germinate on the oak leaves during the summer and fall. Each spore produces a basidium which is divided into four cells each of which develops a single tender, delicate short-lived basidiospore. These spores are disseminated by the air currents and must necessarily come in contact with the pine to cause any infection. Their range is limited because of their delicate nature. They infect the pine needles and the mycelium grows down into the bark and cambium where a gall is initiated that develops during the following season, and produces spores over its surface when 1—3 years old depending on factors surrounding infection and subsequent growth.

The fungus lives as a parasite on living pine and oak trees throughout the entire year. The disease is most conspicuous and probably of most economic importance on the pine trees although oaks of highly ornamental value may be heavily infected. Fortunately, the loblolly pine which is most severely attacked is not as valuable a tree as the slash or longleaf and the latter two have not generally been seriously affected. Some infection occurs on them in nature involving the twigs, larger branches and frequently the trunk but the most serious losses have been encountered in nurseries where, in a certain instance, a 10 per cent loss of seedlings resulted the first year and a 20 per cent infection persisted in 6 year old forests set from this nursery. Complete loss of trees occurs when the main trunks of the 1 year old seedlings become infected. Infection in the nursery is frequent and when it occurs careful culling at transplanting time is necessary. In a certain area of wet, grassy, open oak wood-land near *P. taeda* seed trees in the vicinity of Gainesville, Florida, thousands of 1 to 2 year old seedlings were growing as volunteers. Counts of the 2 year old seedlings made in measured areas selected at random showed 43 per cent dead and remaining upright in position and an additional 21 per cent infected, showing swellings on the stem. Another area in which only one-year old seedlings were counted showed 7 per cent dead plants and 14 per cent infection, indicating possibly that the critical stages were generally predominatingly near the end or slightly after the first year.

The disease as manifest by the galls on the branches and trunks of trees is perennial and the period of spore production by these galls appears in the forest annually at about the same season of the year, varying a few weeks in response to weather conditions. Casual obser-

vations lead one to believe that these galls produce spores every year; however, there are indications that some of them, at least, may skip certain years or possibly sporulate in alternate years. Further studies of this matter are being made. The production of spores on the galls on pines is noticeable most frequently in the Gainesville area in March although an occasional gall may be producing mature spores in February. These fine, powdery, orange-colored spores are carried by air currents, as indicated by infections following prevailing wind direction, and infect oak leaves that grow within a radius of about one-half mile of the diseased pine. Infections on the oaks produce two kinds of spores as previously stated: the summer spores that reinfect oak and the winter spores that must infect pine. The pine becomes infected through the needles during the summer and fall and the fungus grows down the needles into the woody tissue of the twigs where swellings are formed. These swellings develop rapidly during the late winter and spring, usually attaining noticeable size by late summer or fall about a year from the time of infection. Pycnia may appear in the late winter followed by aecia in March. This is the usual seasonal development of the disease on forest trees past the seedling state under average to favorable conditions whereas under adverse conditions no spores may be produced for another year. Infected seedlings between 1 and 2 years old are usually killed before spore production of any kind.

The disease, according to Arthur[1,2] is caused by the fungus *Cronartium quercuum* (Berk.) Miya. This parasite, according to him, causes the formation of short, round, thick and also long, slender aecial galls on branches and trunks of pines in general and also the hypertrophied cones of *P. australis* and *P. palustris*. On the other hand Hedgcock and Long[3], Hedgcock and Hahn[4], Rhoads, et al.[5], agree that the more or less spherical galls on the branches and trunks are caused by *Cronartium cerebrum,* H. & L.; that the long slender galls are caused by *C. fusiforme* H. & H.; and that the galls on the cones are caused by *C. strobilinum* H. & H. Although there is lacking entire accord in the nomenclature, it may be acceptable at this time, if a compromise

[1]J. C. Arthur, *The Plant Rusts* (New York: Wiley & Sons, 1929), pp. 1-437.

[2]J. C. Arthur, *Manual of the rusts of the United States and Canada* (Indiana: Purdue Res. Found., 1934), pp. 1-442.

[3]G. G. Hedgcocock and W. H. Long, "Identity of Peridermium fusiforme with Peridermium cerebrum," *Journal Agricultural Research,* Vol. 2 (1912), pp. 247-250.

[4]G. G. Hedgcock and G. G. Hahn, "Two important pine cone rusts and their cronartial stages," *Phytopathology,* Vol. 12 (1922), pp. 109-122.

[5]A. S. Rhoads and others, "Host relationship of the North American rusts other than Gymnosporangium, which attack conifers," *Phytopathology,* Vol. 8 (1918), pp. 309-352.

could be possible since no additional evidence is to be presented, to use *C. quercuum* (Berk.) Miya., as the binomial for the fungus causing the galls on branches of several species of Florida pines with alternate hosts including a wide range of southern oaks, and *C. strobilinum* H. & H. as the binomial for the fungus causing galls on the cones of at least two species of Florida pines which exclude *Pinus taeda*, the most common host of the previous species of rust.

The yellow pine blister rust appears characteristically on the trunks and large branches of pine trees in the form of spherical, oblong, or linear gall-like swellings, which may completely surround the twigs, branches or trunk. In March yellow-orange blisters appear on the surface of the galls which upon rupturing release quantities of dust-like spores. After the spores are shed, which may be over a period of several weeks, the surface of the galls becomes smoother as the old margins of the now empty blisters weather away and the gall remains inactive, except it may enlarge somewhat during the ensuing season until the following year when spores are again produced. The pycnia producing pycniospores, mostly insignificant in size and otherwise obscure unless especially sought, usually appear in the winter or spring just previous to the time the aecia become promiscuous. There certainly exists the possibility of sex entering into the life cycle of the pathogene at this stage as has been found in many of the other rusts that have been studied in more detail. There is the chance that the taxonomy of the parasites might be straightened out satisfactorily in that forms might be discovered which would account for the present confusion. Until much more detailed and thorough investigations are concluded, however, this solution is only a conjecture.

Infections are less conspicuous on nursery seedlings; in fact they are usually found only by individual inspection because the seedlings are grown in dense populations, their rate of growth is very uniform and, at least until the last stages before the seedlings are killed, infections show only a swelling of the stem as a symptom, occurring anywhere from the soil line to the growing tip. Slight enlargements of the small stem of an exceedingly filiform nature due to infection by the fungus cannot be easily detected even at transplanting time and consequently this early infection on the main stem is carried to the planted forest and will frequently cause the seedling to die after a short period; or at least it will never produce a profitable tree. Severely infected seedlings may become yellow and die in the nursery beds. Those killed in this manner usually appear one in a place because the disease cannot spread from one pine seedling to another. Epidemics may occur however, when seedbed locations are not thoughtfully chos-

en in respect to surrounding pine and oak trees or when certain possible preventive precautions are not exercised.

The leaves are the only parts of oak trees that become infected and the disease can be detected on them by the presence of yellowish blotches with or without small brown specks in the centers on the upper surface of the green leaves. On the lower surface of these blotches there appear numerous small blister-like yellow-orange pustules that bear the summer spores which reinfect oak leaves. Also in these spots are found scattered brown hair-like structures of the fungus. Some of them are barely visible while others are thick and up to one-fourth inch long and produce the spores that cannot reinfect oak leaves but eventually produce secondary spores, basidiospores, which can only infect pines. These spore producing hair-like structures can be found on oaks in March and thereafter throughout the summer. No galls similar in any way to those produced on pine trees are produced on oak trees by this fungus.

The control of yellow pine blister rust in Florida is difficult because the host trees, namely pines and the alternate hosts, some score or more species of oaks, are forest trees well distributed over the state. The galls on the pine branches can be removed annually by pruning, which will reduce the spore production and consequently the infection on oaks. This process in planted forests would eventually reduce infection to a minimum easily within commercial control, if it were carefully carried out over a wide area, but insurmountable difficulties arise when extensive areas of thick woods or cut-over tracts are encountered. Infected pine trees in planted forests can be removed during the thinning operations so that unless infection is severe an almost perfect stand of timber can be produced. In nurseries the application of fungicides has not proven entirely beneficial probably because the applications were not properly timed with the spore production period. Several applications of 2-4-50 bordeaux mixture or some other effective fungicide during February and March in Florida should be beneficial.

The disease can be almost entirely prevented in the seedbed by locating the seedbed more than one-half mile from the closest oaks. If the above distance cannot be obtained, it would be desirable to remove all infection from pine trees for a considerable distance around the seedbeds so as to reduce the infection of oak trees in the vicinity.

LOSS LEADERS AS WEAPONS OF MONOPOLISTIC COMPETITION*

Reinhold P. Wolff
University of Miami

The nature and effects of loss-leaders form one of the most controversial problems in retail distribution. Loss-leaders are articles priced close to or below replacement cost, in order to attract customers to stores in which they appear. It has been alleged on the part of independent merchants that loss-leaders used by chains have been instrumental in driving smaller competitors out of business. On the other hand, large-scale operators deny the monopolistic nature of price leaders and defend the practice as a device to pass on to the consumer savings originating in their larger efficiency as distributors.

Between these conflicting theories the economist is faced with the difficulty of scrutinizing complicated merchandizing and pricing practices as to their effect on a competitive situation that is "imperfect" by its very nature. A customary method of ascertaining the role of chain competition has been to compare retail prices between chain and independent stores.[2] This method, however, has become impractical because supermarkets—both chains and independents—have become an additional factor in food retailing and the difference in pricing methods runs rather between large and small stores than between chain and independent stores.[3]

To ascertain the nature and effects of loss-leaders in food retailing a survey was made in Spring, 1940, on prices of two hundred nationally advertised grocery items in Miami. Prices were checked about six times a month. Twenty stores in the Greater Miami area were included in the survey representing, in addition to typical independent retail stores, chain outlets, supermarkets, and neighborhood stores belonging to chains. The results of the survey emphasize the difficulties of defining the loss-leaders.[4] We found few price leaders of which it can be said that they incur a definite loss on the wholesale price (See Table 3). The characteristic feature of the modern price leaders is rather the fact that it is handled at an unsatisfactory profit margin:

*This study was made possible by a grant-in-aid received from the Social Science Research Council.

[2]Theodore N. Beckman and Herman C. Nolen, *The Chain Store Problem* (New York: McGraw-Hill Book Co., 1938); Jessie V. Coles, *The Consumer-Buyer and the Market* (New York: John Wiley & Sons, Inc., 1938), pp. 207-218.

[3]Reinhold P. Wolff, "The Rise of the Supermarket and Some Marketing Consequences," *Dun's Review,* September, 1940, pp. 8-11.

[4]Ewald T. Grether, "Leaders and Loss-Leaders," *Price Control Under Fair Trade Legislation* (New York: Oxford University Press, 1938).

i. e., a profit not large enough to include an appropriate share in the store's general overhead.

Taken in this broader sense "loss-leaders" were found in all types of stores. But we discovered that price leaders play a different role in the various outlets. They are most numerous in supermarkets and large stores and less numerous in the neighborhood outlets of chains and in small independent stores. From Table 1, tabulating frequency of the use of deeply cut loss-leaders, it also appears that the frequency of loss-leader use is largest in the super stores and is smallest in the neighborhood stores.

TABLE 1.—79 Articles Frequently Used as Loss-Lealers in Miami

	Number of Articles Used as Loss-Leaders		Total	Number of Survey Price Checks at Deeply Cut Prices	
	Number	Percent of Total		Number	Percent of Total
By Supermarkets	43	54	3935	345	8.7
Chains (Neighborhood Units)	24	30	2961	126	4.2
Large Independents	29	37	3049	115	4.9
Small Independents	17	21	8337	115	1.3

Smaller stores have occasional weekend specials while supermarkets use the same low quotations all over the week. From Table 2 it appears that generally the larger stores cut prices deepest, although in some instances smaller outlets carry spectacularly cut bargains for limited periods of time.

The supermarket has the longest bargain list. We found that hundreds of items of nationally advertised food items were carried at very narrow quotations close to the wholesale prices and in some instances below the price at which the independent retailer buys the commodity. About fifty percent of typical supermarket prices are carrying a gross margin of less than ten percent over cash and carry wholesale quotations. Even if it is realized that supermarkets, as mass buyers, purchase, on the average, one to five percent below the cash and carry wholesale quotations, we find that their mark-up on standard groceries is close to or below their average overhead expense, which is at least thirteen percent.

Chain stores may be clearly divided in two categories. One group, the neighborhood store unit, carries prices on advertised items

that are not very different from those of independent retailers (See Tables 2 and 3). Another group, the chain store supermarket, has a long list of aggressive price leaders and may outdo independent super stores both as to the number of loss items carried and as to the depth of the price cut. We have tabulated these stores along with the independent super stores.

The large independent stores, not qualifying as super stores, were found not to use price leaders to the same extent as supermarkets but more aggressively than chain neighborhood stores. But they are certainly far ahead of their smaller competitors both in number of bargains and in depth of price cutting activities, although they frequently extend credit and delivery services. The smaller independent stores were found to use loss-leaders sparingly (See Tables 2 and 3). Their relatively high mark-ups in standard groceries have to be explained by the insulation from price competition, which location and extra services secure.

To evaluate these findings in the light of economic theory is not an easy undertaking. It has to be brought to mind that standard articles with a definite known price to the consumer are not the only items which are passed over retail counters. Such nationally advertised items form the backbone of profits of the old-time grocery corner store. They represent only a portion of the modern combination store's inventory, which contains, in addition to nationally advertised dry groceries, fruit, vegetables, dairies, meats, and delicatessen. Still more limited is the role of the nationally advertised grocery product in large supermarkets. Super stores stock about three thousand to four thousand various articles, brands, sizes, and qualities. They have come to look for profits more in private brands or lesser known national brands, than in the nationally known best sellers.

Yet emphasis of price competition is on the national brand, because these items are the only ones sufficiently standardized to afford exact price comparisons by the consumer. At this point the monopolistic effect of the price leader comes in. Supermarkets and large independent stores carry thousands of different items. They are able to use the advertised best seller to beat their smaller competitors. Cutting the well-known consumer prices on two hundred to three hundred best selling national items gives the stores a reputation of reasonableness. The consumer is unable to ascertain to what degree the same reasonableness prevails as to the puzzling variety of private brands, off-sizes, and many other items on which she is unable to compare quotations. Thus the price cutting of standard articles throws a smoke screen over the large store's price structure and makes it uncomparable with their competitor's mark-ups.

The smaller unit cannot follow suit. It has to carry the best sellers and is unable to stock thousands of other items to make up for the loss. Using all best sellers as bargains would depress the smaller unit's margins to the point of unprofitability of the whole grocery department. In fact, competition has had this effect on many independent stores (see Table 2) and on neighborhood units of chain systems as well. The effects of the loss leader are comparable to local price discriminations against smaller competitors. The larger stores may operate at higher than average profit margins even if locally applying loss-leaders; the smaller competitor has to operate at average mark-ups. Forced to adopt their price structure to considerable price cutting of national items, the smaller stores have seen their grocery departments moving from the center of store profitability to the periphery. The grocery business has been lost to the large operators and small stores are gradually shifting to meat and specialties.

We are thus confronted with a situation which is quite typical, for it is the form that competition assumes in modern society.[5] Large and small enterprises do not fight with equal weapons on the plane of competition. The price cut, which is a deadly weapon in the hand of the large competitor, is a clumsy tool in the hands of the small independent. By the force of price competition the large operator is not only able to drive smaller competitors out of the field of his operation but he is also in a position to build up behind the walls of this price leadership large areas where price competition is less active.

Such areas of lessened competition exist in the field of off-brands, private brands, and lesser advertised brands of which supermarkets stock tremendous quantities. The competition here is "imperfect" because buyers are not able to make exact comparisons of prices. "Perfect" competition presupposes information of the buyers as to the prices quoted. That does not mean that there is no competition at all, because buyers compare quotations on non-advertised items to the price leaders. But they are unable to make exact measurements which gives the seller an opportunity of handling the goods at mark-ups which are ten to fifteen percent higher than nationally advertised items.

In conclusion it appears that as in producing industries, competition in the retail trade is growing more complex through the appearance of large-scale operators. The loss-leader practice has invigorated price competition in some fields, but has lessened it in others. Like production, modern distribution is operating in the twilight zone of competition and monopoly.

[5]E. H. Chamberlin, *The Theory of Monopolistic Competition,* 1933; A. R. Burns, *The Decline of Competition* (New York: McGraw-Hill Book Co., 1936).

TABLE 2.—PRICE VARIATIONS IN VARIOUS TYPES OF STORES

	Wholesale*	Supermarket†		Chain Stores‡		Large Independents		Small Independents	
		Typical	Lowest	Typical	Lowest	Typical	Lowest	Typical	Lowest
Article	$	$	$	$	$	$	$	$	$
Cocoa Hershey 1 lb.	.112	.15	.15	.15	.15	.15–.17	.12	.15–.18	.15
Cocoa Baker ½ lb.	.10	.08	.08	.10	.08	.10	.10	.10	.10
Coffee Maxwell House 1 lb.	.225	.25	.25	.23–.25	.24	.25	.24	.27	.23
Coffee Sanka 1 lb.	.31	.35	.30	.35	.35	.33	.31	.35–.37	.35
Tea Tetley 1¾ oz.	.07	.10	.09	.10	.10	.33	.31	.35–.37	.35
Cornflakes Kellogg 8 oz.	.054	.065	.055	.06–.075	.05	.06–.075	.055	.075	.05
Post Toasties 8 oz.	.056	.065	.055	.06–.075	.06	.06–.075	.06	.075	.075
All Bran Kellogg 11 oz.	.104	.125	.115	.125	.115	.125	.115	.13–.15	.125
Quaker Oats 1 lb. 4 oz.	.075	.085	.085	.085–.10	.085	.085–.095	.085	.10	.10
Wheatena 22 oz.	.193	.23	.23	.25	.23	.35	.25	.25	.25
Flour Goldmedal 5 lbs.	.24	.25	.25	.27–.31	.25	.25–.29	.25	.27	.25
Flour Pillsbury Best 5 lbs.	.23	.25	.25	.27–.31	.25	.29	.25	.25–.27	.21
Baking Powder Calumet 6 oz.	.072	.09	.09	.10	.09	.09–.10	.09	.10	.10
Baking Powder Rumford 6 oz.	.108	.13	.13	.12–.15	.12	.13	.13	.15	.10
Pudding Jell-O 3½ oz.	.048	.05	.04	.05	.05	.057	.05	.057	.05
Syrup Log Cabin 12 oz.	.165	.19	.19	.17–.23	.17	.20–.25	.19	.21–.25	.19
Syrup Karo Red 1½ lb.	.123	.15	.13	.13–.17	.13	.17	.13	.17	.13
Grape Juice Welch 1 pt.	.183	.23	.15	.23–.25	.23	.23	.21	.25	.23
Tomato Juice Campbell 14 oz.	.057	.075	.066	.075	.065	.075	.055	.07–.083	.06
Canned Pineapple Libby No. 2½ 1 lb. 14 oz.	.175	.21	.19	.21	.21	.21–.22	.17	.25	.25
Canned Pineapple Delmonte No. 2½	.17	.21	.19	.19	.19	.21	.21	.21–.25	.21
Peaches Libby No. 2½	.146	.17	.125	.145	.145	.19	.133	.17–.21	.17
Pears Delmonte No. 2½	.188	.21	.145	.19–.21	.19	.22–.23	.22	.21–.25	.20
Apple Sauce Musselman 1 lb. 1 oz.	.063	.055-.065	.05	.065–.075	.065	.075–.10	.083	.10	.10
Corn Niblets 12 oz.	.095	.10	.10	.125	.095	.10–.125	.10	.15	.15
Corn Delmonte 1 lb. 4 oz.	.094	.095	.095	.125	.125	.115	.115	.15	.125
Tomatoes Delmonte 1 lb 3 oz.	.121	.115-.135	.115	.125	.125	.15	.145	.15	.15
Peas Green Giant 1 lb. 1 oz.	.135	.145	.105	.145–.17	.145	.145–.17	.145	.17–.18	.17

TABLE 2.—(*Continued*)

Pork and Beans Campbell 1 lb.	.066	.07	.07	.075	.075	.10	.075	.10	.075
Pork and Beans Friends 1 lb. 11½ oz.	.154	.175	.165	.19	.19	.17	.17	.19–.21	.18
Tomato Soup Heinz 10 oz.	.08	.083	.083	.083	.083	.083	.083	.10	.083
Tomato Soup Campbell 10½ oz.	.067	.085	.075	.075–.085	.075	.07–.085	.065	.083	.08
Chicken Soup Campbell 10½ oz.	.092	.10	.10	.10	.10	.10	.10	.12	.12
Spaghetti Franco-American 15¾ oz.	.072	.083	.083	.083	.083	.083	.083	.10	.10
Corn Beef Libby 12 oz.	.179	.19	.165	.19–.21	.19	.19	.16	.19–.22	.18
Spam 12 oz.	.245	.25-.27	.23	.27	.23	.25–.29	.27	.27–.29	.27
Dog Food Ken-L-Ration 1 lb.	.071	.075	.075	.083	.075	.083	.083	.083	.083
Baby Food Clapps 4½ oz.	.063	.075	0.75	.075–.083	.075	.083	.063	.083	.083
Shortening Spry 1 lb.	.165	.19	.18	.17–.19	.17	.19–.20	.19	.19–.23	.19
Shortening Spry 3 lbs.	.457	.49	.43	.45–.53	.43	.49	.43	.59	.49
Salt Morton Plain 1 lb. 10 oz.	.064	.08	.075	.10	.08	.08	.075	.10	.075
Toilet Soap Palmolive	.053	.057	.055	.055	.045	.057	.05	.066	.063
Household Soap Flakes Lux 5 oz.	.083	.083	.083	.083	.083	.08–.10	.08	.10	.10
Household Soap Flakes Chipso 1 lb. 6 oz.	.191	.20	.18	.20	.20	.23	.21	.23	.19
Household Soap Flakes Ivory 12½ oz.	.193	.21	.21	.23	.20	.21–.23	.21	.23	.23
Cleanser Old Dutch 14 oz.	.063	.075	.066	.065–.075	.07	.075	.075	.083–.10	.075
Scott Towels	.079	.083	.083	.083	.083	.083	.083	.10	.083
Scott Tissues	.063	.075	.06	.065–.083	.065	.083	.025	.083	.083
Popular Cigarettes 1 carton	1.125	1.15	1.15	1.19	1.15	1.19	1.15	1.19–1.20	1.15
Canned Milk Carnation 14½ oz.	.065	.065	.065	.065	.065	.065	.06	.07	.065

*This is the lowest price quoted to retailers by cash and carry wholesalers. Supermarkets and chains buy on the average at five to eight percent below this price.

†Including super stores of chains. Store volume above $250,000 anually.

‡Excluding chain super stores with volume above $250,000.

TABLE 3.—Gross Margins* in Various Types of Stores
(in percent of the retail price)

Article	Supermarkets Typical	Supermarkets Lowest	Chain Store Typical	Chain Store Lowest	Large Independents Typical	Large Independents Lowest	Small Independents Typical	Small Independents Lowest
Cocoa Hershey 1 lb.	25	25	25	25	25–34	6	25–31	25
Cocoa Baker ½ lb.	20	0	20	0	20	20	20	20
Coffee Maxwell House 1 lb.	10	10	2–10	6	10	6	17	2
Coffee Sanka 1 lb.	13	3	13	13	6	0	10–13	20
Tea Tetley 1¾ oz.	30	22	30	30	30	30	30	30
Cornflakes Kellogg 8 oz.	17	2	10–28	–8	10–28	2	28	–8
Post Toasties 8 oz.	14	2	7–25	7	7–17	7	25	25
All Bran Kellogg 11 oz.	17	10	17	10	17	10	20–30	17
Quaker Oats 1 lb. 4 oz.	12	12	12–25	12	12–21	12	25	25
Wheatena 22 oz.	16	16	23	16	23	23	23	23
Flour Goldmedal 5 lbs.	4	4	11–23	4	4–17	4	11	4
Flour Pillsbury Best 5 lbs.	8	8	15–25	8	21	8	8–15	10
Baking Powder Calumet 6 oz.	20	20	28	20	20–28	20	28	28
Baking Powder Rumford 6 oz.	17	17	10–28	10	17	17	28	–8
Pudding Jell-O 3½ oz.	4	–20	4	4	19	4	16	4
Syrup Log Cabin 12 oz.	13	13	3–26	3	17–20	13	20–34	13
Syrup Karo Red 1½ lbs.	18	5	5–28	5	28	5	28	5
Grape Juice Welch 1 pt.	20	–22	20–27	20	20	13	27	20
Tomato Juice Campbell 14 oz.	24	14	24	12	24	–4	19–31	5
Canned Pineapple Libby No. 2½ 1 lb. 14 oz.	17	8	17	17	17–20	–3	43	43
Canned Pineapple Delmonte No. 2½	19	11	11	11	19	19	19–32	19
Peaches Libby No. 2½	14	–17	0	0	23	–10	14–30	14
Pears Delmonte No. 2½	11	–30	1–11	1	15–23	15	11–29	6
Apple Sauce Musselman 1 lb. 1 oz.	–15 to 3	–20	3–16	3	16–37	24	37	37
Corn Niblet 12 oz.	5	5	24	0	5–24	5	37	37
Corn Delmonte 1 lb. 4 oz.	1	1	25	25	18	18	40	25
Tomatoes Delmonte 1 lb. 3 oz.	5–10	–5	3	3	19	17	19	19
Peas Green Giant 1 lb. 1 oz.	7	–29	7–21	7	7–21	7	21–25	21
Pork and Beans Campbell 1 lb.	6	6	12	12	34	12	34	12

TABLE 3.—(*Continued*)

Pork and Beans Friends 1 lb. 11½ oz.	12	7	19	19	9	9	19–27	14
Tomato Soup Heinz 10 oz.	8	8	8	8	8	8	20	8
Tomato Soup Campbell 10½ oz.	21	11	11–21	11	11–21	3	19	16
Chicken Soup Campbell 10½ oz.	8	8	8	8	8	8	23	23
Spaghetti Franco-American 15¾ oz.	13	13	13	13	13	13	28	28
Corn Beef Libby 12 oz.	6	–8	6–15	6	6	16	6–18	5
Spam 12 oz.	2–9	–6	9	–6	2–16	9	9–16	9
Dog Food Ken-L-Ration 1 lb.	5	5	14	5	14	14	14	14
Baby Food Clapps 4½ oz.	16	16	16–24	16	24	0	24	29
Shortening Spry 1 lb.	13	8	3–13	3	13–18	13	13–28	13
Shortening Spry 3 lb.	7	–5	7–14	–5	7	–5	23	7
Salt Morton Plain 1 lb. 10 oz.	20	15	36	20	20	15	36	15
Toilet Soap Palmolive	7	4	4	–12	7	–6	20	16
Household Soap Flakes Lux 5 oz.	0	0	0	0	4–17	–4	17	17
Household Soap Flakes Chipso 1 lb. 6 oz.	5	–6	5	5	17	9	17	0
Household Soap Flakes Ivory 12½ oz.	8	8	16	4	8–16	8	16	16
Cleanser Old Dutch 14 oz.	16	5	3–16	10	16	16	24–37	16
Scott Towels	4	4	4	4	4	4	21	4
Scott Tissues	10	–5	3–22	3	22	–150	22	22
Popular Cigarettes 1 carton	2	2	5	2	5	2	5	2
Canned Milk Carnation 14½ oz.	0	0	0	0	0	–8	7	0

*Margins are calculated on the basis of uniform wholesale price of Table 1. Actual profit or loss margins differ, since super and chain stores may buy below the prices quoted to smaller retailers.

SUGGESTIONS IN TECHNIQUE FOR THE BIOLOGICAL LABORATORY.

George G. Scott
Rollins College

1. Mounting of Demonstration Dissections.

After the dissection is completed it is set aside to harden in a preservative such as 5% formaldehyde. The width and length of the inside front wall of the museum jar to be used should be determined, and a shallow tray about 0.5 inch deep and the same width and length as above noted should now be found or made.

Melt enough hard paraffin to make a slab or plate about 1 cm. thick when the bottom of the tray is covered with melted paraffin. Before putting it in the tray, add to the melted paraffin a liberal amount of lamp-black and a lump of beeswax and mix thoroughly. Pour the melted black mass into the tray and allow it to cool partially, especially the surface. On the thin hardened surface place the dissection and arrange it as it is to appear finally. Press the thicker parts of the dissection down into the soft paraffin and secure it at essential points by pins extending into the paraffin plate. Harden the paraffin with ice water. Attach labels or numbers to significant parts by means of pins, or better, small brass nails. The trimmed and cleaned preparation can now be placed in the museum jar against the back wall. Fill the jar with preservative and put on the cover.

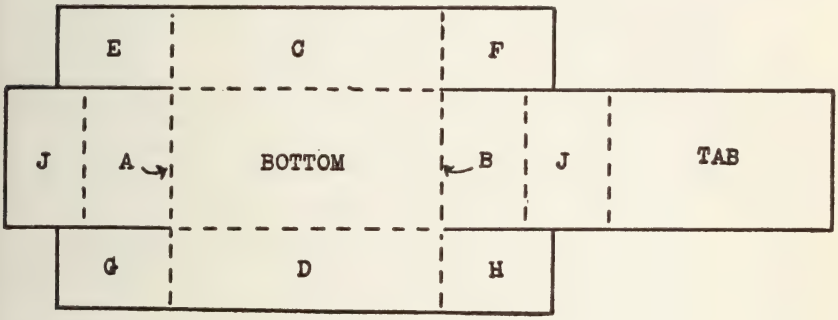
It is easier to attach dissections to such a paraffin plate than to a sheet of glass, and white tissues show to good advantage against the black background. An explanation of numbered parts may be posted on the outer back wall of the jar. Such preparations are useful in class room work and teachers can easily determine what the student knows by using unlabelled, but numbered, preparations in practical examinations.

2. Containers for Paraffin Blocks.

After tissues have been fixed, washed, dehydrated and infiltrated with paraffin, they are often placed in Syracuse dishes filled with melted paraffin which, after hardening makes a disk containing the embedded tissue. However, the containers or boxes described have been found superior to glass dishes.

Obtain a sheet of very thin metal such as aluminum or copper. Roofers carry a material called "copper skin" which is not only inexpensive but suitable for this purpose. The "skin" consists of very thin copper sheeting covered with coarse paper infiltrated with asphaltum, and most of the paper coat can be torn off. If the pat-

tern indicated by Figure 1 is used, the container or "boat" may be easily cut out with scissors and then folded into the desired shape. The long end is a tab on which data can be recorded with a hard pencil. These metal "boats" are sturdy, stable upon being filled with melted paraffin, are easily lowered into ice water. The preparation hardens quickly because of the metal walls of the container. When ready for section cutting the walls may be easily unfolded from the paraffin block, the label can be erased, the tab smoothed out with a flat piece of metal. The walls are then re-folded into a box ready for further use.



3. A Substitute for Cover Glasses.

Because of the war in Europe the price of cover glasses used in completing the preparation of stained material for microscopic examination has so increased that attempts have been made to find a satisfactory substitute for the usual imported cover glasses. Within the last few months notes have appeared in Science[1] relative to the use of isobutyl methacrylate polymer as a substitute for balsam and cover glasses. This substance is easily soluble in xylene, in which stained sections are cleared and made ready for balsam and the cover glass. A syrupy solution of the isobutyl compound is made with xylene and this is easily drawn up into a dry medicine dropper. The stained slide is taken from the xylene bath and fleeded with the isobutyl-xylene mixture. After some hours a glass-like coating is formed. The refractive index of the polymer is about the same as that of glass. Sections prepared in this way by the present writer in April of year show no sign of cracks in the covering. One writer in Science found that the stain was affected, and that the preparation was less clear and somewhat faded. To test this, four slides of a variety of mammalian organs were stained in a similar manner. Two of each set were covered with balsam and cover glasses and the other two slides were flooded with isobutyl-xylene mixture. In a few days the latter were faded and

distinctly inferior to those of the first lot. Further experimentation toward finding a satisfactory substitute for cover glasses is indicated. However, in an emergency, slides *could* be completed by this method, immediately studied, stored and later restrained and covered as usual, when cover glasses were again available.

4. A Home-made Constant Temperature Oven.

An apparatus, heated by electricity and provided with a thermostat so that a constant temperature may be attained is very useful in every biological laboratory, especially if there is considerable work being done in making slides of embryological or histological material. However, such constant temperature ovens are high in price. Because of this fact, the writer planned the following experiment. A metal box of stiff galvanized sheeting, lined throughout with one quarter inch thick asbestos sheet was made by a local roofing company. The box was 14 inches long by 11 inches wide by 11 inches high, with metal legs two inches long at each corner. A small hole in the center of the top was made for the insertion of a chemical thermometer. Metal doors on hinges were made for the front opening of the box. An old heating coil of about the right size was found for the floor of the oven. A temperature gauge and thermostat from an old electric range made a very successful installation in the "oven". The result was that the feed cord could be plugged into a wall socket, and although the temperature gauge is in degrees Fahrenheit, when in use the operator actually observes temperatures by the centigrade thermometer, the bulk of which is within the oven. And after a short time the temperature can be properly adjusted. To illustrate, a commonly employed temperature in paraffin embedding is 55°C. Starting with a cold oven this may be arrived at in less than an hour, and once obtained, the bath temperature remains constant indefinitely. The oven operates at other temperatures also.

The total cost of this very useful apparatus is very small as compared with those of laboratory supply houses.

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[1]H. C. O'Brien and Robert Hance, *Science,* Vol. 91 (1940), p. 412. Suntzeff and Smith, *Science,* Vol. 92 (1940), p. 17. R. A. Groat, *Science,* Vol. 92, (1940), p. 268.

AN IMPROVED METHOD FOR DETERMINING PRIME FACTORS

GUY G. BECKNELL
University of Tampa

In a previous paper[1] the writer has discussed in detail a method for finding several prime factors of a number at a single operation. Four methods for carrying out rapid division also were introduced for cases in which there was known to be no remainder. These four methods corresponded to divisors with terminal digits 1,3,7 and 9.

In the general method for determining prime factors the number to be factored was used as the dividend and a second number made up as the product of known primes, and designated as the test-product, was used as a sort of divisor. The only hindrance to the power and usefulness of this method lies in the fact that the magnitude of the number to be factored, when used as the dividend, sets a limit to the magnitude of the divisor and thus, also, sets a limit to the number of prime factors for which trial may be made at one operation.

In the revised method, here to be discussed, the roles of the number to be factored and the test-product are interchanged so as to make the product of known primes the dividend. This allows trial to be made for any number of primes at a single operation, the number of them selected being merely a matter of convenience. Justification for this reversal of the process is found in the following theorem proved in the introductory paper.

Theorem 5. If a composite whole number, $10t + u$, contains any factor of $10n + 1$, where all the symbols are integers, then the number t - nu will contain every factor common to the other two.

At no place in this theorem, or in its proof, is any assumption made as to the identity of either number as the one being tested for prime factors. The only proviso implied is that the divisor shall have a terminal digit of 1. In the process suggested by this theorem the function $t - nu$ is formed repeatedly, deleting one or more end-digits of the dividend at each stage of the process, and this method is continued until a *mimum residue* is obtained.

Another theorem very similar to the one just given is equally convenient, and it will now be stated and proved.

[1]G. G. Becknell, "Tests for Determining Prime Factors," *Proceedings of the Florida Academy of Sciences*, Vol. 4 (1939), pp. 231-45.

Theorem 6. If a composite whole number, $10t + u$, contains any factor of $10n + 9$, then the number $t + (n + 1)u$ will contain every factor common to the other two.

For, let $10n + 9$ have two or more prime factors, and let any one of these be $10q + r$, q being integral and r being the digit 1, 3, 7 or 9. The other factor, whether prime or composite, then must end in the digit 9, 3, 7 or 1 respectively. Hence,

$10n + 9 = s(10q + r)$, where s is integral. Now let

$10t + u = m(10q + r)$, where m is integral. Then,

$(10t + u)\ (n + 1) + t = m\ (n + 1)\ (10q + r) + t$; and

$t + (n + 1)\ u = m\ (n + 1)\ (10q + r) - t(10n + 9) =$

$(10q + r)\ [m\ (n + 1) - st.]$

Therefore, since the quantity in brackets is integral, the number $t + (n + 1)u$ contains the factor $10q + r$, and the theorem is proved.

For the purpose of division, where there is known to be no remainder, two theorems from the introductory[2] paper will be employed. These will be restated here for clearness in the work that follows.

Theorem 1. If any whole number, $10t + u$, is divisible by $10n + 1$, then the number $t - nu$ is also divisible by $10n + 1$.

Under this theorem the reduction process is identical with that of Theorem 5, except that the minimum residue is 0. Then, the quotient of $10t + u$ by $10n + 1$ is found as follows:

Rule for Quotient (Theorem 1). Form the number consisting of the deleted end-digits in reverse order. This is the quotient.

Theorem 2. If any whole number, $10t + u$, is divisible by $10n + 9$, then the number $t + (n + 1)u$ is also divisible by $10n + 9$.

In this case the reduction process is like that of Theorem 6, the minimum residue being $10n + 9$ itself.

Rule for Quotient (Theorem 2). Starting at the last end-digit in the reduction process substract each in order from 9, except the first which is to be substracted from 10.

It will be noticed that these theorems deal only with numbers having terminal digits 1 and 9. But numbers ending in 3 and 7 may be multiplied by 3 to bring them under the rules without introducing any difficulties whatever.

By the use of a large test-product as dividend, limited here to 18 digits, the three tables of the former paper, which employed 84 separate operations, are replaced by a single table of only 25 operations. In the revised table the primes occur in precise order of magnitude, and so a convenient list of primes is presented for inspection. These test-products contain all the primes from 7 to 1013 inclusive, and the

[2]Ibid.

number of factors included in a single product varies from twelve, in the case of the smallest factors, down to six with the largest.

As the first example of the method suggested let us find the prime factors of 45,692,081. Inspection shows that there are no factors below 7. So, setting down the first test-product from the table as dividend and the given number as divisor we have: test-number $= n =$ 4,569,208; and the reduction process follows.

```
20496326086283047  (4569208).  Divisor = 45,692,081.
          31984456
         576643848
          36553664
        3221110720
          9138416
        623072691
          4569208
         57738061
          4569208
        491204598
         36553664
       2012566795
         22846040
        178410639
         41122872
   -3)-23281809
          7760603
         45692081
     2)37931478
         18965739
         45692081
     2)6465782
          3232891
         45692081
          4245919
         45692081
   2)49938
   3)24969
          8323
```

In this case our minimum residue from the reduction process is 23,281,809; but this being a multiple of 3 it reduces to 7,760,603. By Theorem 5 this number must contain every factor common to the original number and the first test-product. So, substracting it from our original number and dividing by two we obtain 18,965,739. Since this ends in the digit 9 we may add it to our original number and delete the final cipher. Again dividing by 2 we get 3,232,891. Subtracting this from the original number again we delete the cipher; and since the difference ends in 9 we may add it to the original number and delete the three terminal ciphers. Then, by dividing by 2 and by 3 we get 8323 as the smallest number yet obtained which contains all the factors common to the original number and the first test-product.

TABLE OF TEST-PRODUCTS

1)	7·11·13·17·19·23·29·31·37·41·43·47	=	20,496,326,086,283,047
2)	53·59·61·67·71·73·79·83·89	=	38,655,288,426,304,091
3)	97·101·103·107·109·113·127·131	=	22,125,549,654,501,673
4)	137·139·149·151·157·163·167·173	=	316,773,187,163,046,517
5)	179·181·191·193·197·199·211	=	9,879,251,463,499,721
6)	223·227·229·233·239·241·251	=	39,049,078,408,188,253
7)	257·263·269·271·277·281·283	=	108,538,288,030,848,139
8)	293·307·311·313·317·331·337	=	309,619,196,508,457,007
9)	347·349·353·359·367·373·379	=	796,229,312,542,859,009
10)	383·389·397·401·409·419	=	4,064,625,951,224,869
11)	421·431·433·439·443·449	=	6,860,596,063,872,959
12)	457·461·463·467·479·487	=	10,626,236,358,872,441
13)	491·499·503·509·521·523	=	17,092,564,102,090,369
14)	541·547·557·563·569·571	=	30,150,641,449,095,443
15)	577·587·593·599·601·607	=	43,889,293,834,596,251
16)	613·617·619·631·641·643	=	60,888,412,234,461,547
17)	647·653·659·661·673·677	=	83,850,965,748,659,689
18)	683·691·701·709·719·727	=	122,610,116,602,749,401
19)	733·739·743·751·757·761	=	174,123,625,045,688,707
20)	769·773·787·789·797·809	=	237,993,125,379,536,343
21)	811·821·823·827·829·839	=	315,199,737,746,363,081
22)	853·857·859·863·877·881	=	418,706,125,428,900,509
23)	883·887·907·911·919·929	=	552,511,361,260,261,967
24)	937·941·947·953·967·971	=	747,167,199,075,879,979
25)	977·983·991·997·1009·1013	=	969,878,888,197,165,169

It still remains to be seen whether it is possible to reduce this number still lower. We may combine it with any of the numbers

previously obtained. Since it ends in digit 3 it will be found advisable to substract it from 7,760,603. The reduction, then, proceeds as follows:

```
   7760603
      8323
 4)775228
   193807
     8323
   20213
    8323
   1189
    8323
 6)7134
   1189
```

Finally, the number 1189 is found. Combining this again with 8323 by subtraction and then dividing by 6 we obtain 1189 once more. This shows that 1189 is our absolute minimum, so that we must seek its factors from the group in the first test-product; namely: 7,11,13,17,19,23,29,31,37,41, 43, and 47. Inspection shows that 29(41)=1189. Hence 29 and 41 are the first two prime factors of 45,692,081, and this must now be divided by 1189. The process is that under Theorem 2 and it is carried out as shown. Our divisor being 1189, $n = 118$, and $n + 1 = 119$.

```
45692081 (119)
     119
   69327
    833
  57765
   595
  6371
  119
 4756
 714
1189
```

Since our reduction process ends with the divisor, 1189, we obtain the quotient by subtracting the terminal digits from 9, except for the first which is subtracted from 10. Hence, the quotient is 38,429. This must be tested again for divisibility by 29 and 41; so we must divide once more by 1189. This may be done by ordinary division, or we may use the same method as before; thus:

```
   38429 (119)
   1071
   4913
   357
 4)848
 4)212
    53
```

Divisor 1189.

The reduction process produces the prime 53, so we conclude that 38429 does not contain 29 or 41 as a factor.

The next stage in the search for prime factors of 38429 is to test it against the second test-product. For this we use the process of Theorem 6. Then, $n = 3842$, and $n + 1 = 3843$.

38655288426304091 (3843) Divisor = 38429.

3843
634252
7686
271111
3843
430954
15372
8858467
26901
2912747
26901
318175
19215
551032
7686
562789
34587
690865
19215
3888301
3843
392673
11529
6)50796
6)8466
1411
38429
4)3984
12)996
83

Here, the minimum residue under the reduction process is 50,796, which may be factored down by inspection to 1411. Since this number ends in digit 1, it is an advantage to add our original number, 38,429, and delete the final cipher. This produces an even number which factors down by inspection to 83. This, then, is the third factor of 45,692,081, since 83 is among the primes in the second test-product.

Next, we must divide 38,429 by 83. To do this we multiply each by 3 to bring them under the process of Theorem 2. Then, the divisor being 249, $n = 24$, and $n + 1 = 25$. The dividend is 3(38429).

```
115287..(25).  Divisor = 249.
  175
 1703
   75
 1245
  125
  249
```

This process reduces to the divisor, 249, as it should, and so the quotient, under the rule of Theorem 2, is 463. Inspection of the table of primes shows 463 to be prime. Hence, 45,692,081 = 29 (41) (83) (463).

This example illustrates most of the arithmetical devices that may be used to reduce the product of primes to a minimum. However, there is another quite obvious one that appears several times in the following example.

Find the prime factors of 2,793,813,151 contained in the first test-product. Here, our test-number = n = 279,381,315. The reduction process, then, is as follows:

```
20496326086283047  (279381315).  Divisor = 2793813151.
      1955669205
     30652959099
      2514431835
     60550864074
      1117525260
     94937561147
      1955669205
     47538086909
      2514431835
    202239376855
     1396906575
    18827031110
    279381315
 -4)-91111004
     22777751
     182689
      4508851
       182689
    2)469154
      234577
      182689
     8)51888
      6)6486
        1081
```

```
    2793813151
    22777751
     516038051
      22777751
27)  4932603
      182689
        1081
      18377
        1081
   16)17296
       1081
```

Here, the minimum residue is 91,111,004, which factors down to 22,777,751. This, when multiplied by 100 and subtracted from the original number, deletes the initial digit; and when we subtract 22,777,751 from this, we eliminate the two terminal ciphers.

The remainder is factorable by 3 three times, reducing our key number to 182,689.

When the latter is multiplied by 100 and subtracted from 22,777,751 we eliminate the initial digit again, and the difference, ending in digit 1, may be added to 182,689 to eliminate the final cipher. Thus, the sum, factored by 2, reduces to 234,577. When 182,689 is subtracted from this the difference factors down to 1081, which may be an absolute minimum. To decide this we add it to our next smallest reduction number, 182,689,

eliminating the terminal cipher. Again substracting from this 1081, we find that the difference reduces once more, by factoring to 1081, showing it to be an absolute minimum.

Finally, inspection of the first test-product shows that $1081 = 23(47)$. Hence, these are the factors sought in the first test-product.

Other test-products may be added to the table for primes above 1013. However, if these products are not to exceed 18 digits the number of factors used must be less than six, the minimum number now in the table. It should clearly be kept in mind that the methods here illustrated are applicable in factoring any number, however large, the factors being of any magnitude, and tests to be made for any number of them at a single operation.

PARASITES OF FRESH-WATER FISH OF SOUTHERN FLORIDA

Ralph V. Bangham
College of Wooster, Wooster, Ohio

Collections and preliminary studies of the fish parasites were made from February to June, 1938, while the writer was on a semester's leave from the College of Wooster. The staff of the Bass Biological Laboratory furnished laboratory facilities where much of the preliminary work of examination and identification of parasites was done, and also assisted in the collection of fish. During this investigation 1380 fish belonging to sixteen families and forty-five species were examined. Of this number 1,218 or 88.2 per cent were found to harbor at least one species of parasite. The report on the parasites of eight species of the family Centrarchidae has already been published (Bangham, 1939).

There is very little literature available for fish parasites of this region. Mueller (1936, 1937) gave the results of his studies on gill flukes and parasitic copepods collected chiefly from fish secured at the Myakka River near Sarasota. Dr. H. W. Manter and other workers have made extensive studies on the trematodes of marine fishes in the vicinity of the Tortugas Biological Laboratory of the Carnegie Institution. The forms carried by marine fish, in most cases, belong to different species from those in freshwater fish. Manter (1938) reported on the parasites of a collection of trematodes from amphibian hosts of Florida. *Clinostomum marginatum* (Rud.) was the only trematode taken which is also found in fish. In the report on the parasites of the Centrarchidae (Bangham, 1939) the large number of larval, encysted nematodes and strigeid metacercariae encountered were mentioned. The same condition is true for most of the other Florida fish included in this report. Many more larval parasites were taken in the Florida fish than during the Lake Erie survey (Bangham and Hunter 1939). Most of these larval parasites had fish-eating birds as their definitive hosts. A similar situation was encountered in fish examined from lakes in Algonquin Park, Ontario (Bangham, in press). In these Canadian lakes many of the same species of birds found in Florida have their nesting sites and carry parasites from one locality to the other. *Contracaecum spiculigerum* Rud. was secured from mesentery cysts of 28 species of Florida fish. It has also been reported from fish in other areas. Venard (1940) took it from many species of fish. The life cycle of this form was determined by Thomas (1937. *C. spiculigerum* was not taken from Algonquin Park or Lake Erie fish. The

bass cestode, *Proteocephalus ambloplitis* (Leidy), found as encysted larvae in great numbers in the fish of Algonquin Park lakes containing smallmouth bass was not taken from Florida fish. There were not as many different species of parasites obtained from the Florida fish as from those farther north but the degree of infection was often heavier.

Fish used in this survey were obtained chiefly by seine hauls. Representatives of most of the species examined were taken from the many ponds and roadside ditches in the vicinity of Englewood where the Bass Biological Laboratory is located. Near the end of the working period many of the areas became dry and large numbers of fish died. On the first visit to Lake Okeechobee fish were taken by seines from shallow water along canals in the lake. Others were obtained from canals outside of Lake Okeechobee. On three subsequent trips to this area fish were purchased from commercial fishermen. On two visits many species of larger fish were taken from the Myakka River within the area of the State Park south-east of Sarasota. One series of collections was made from the Everglades canals. In many regions of this canal system the water was too brackish for fresh-water fish, but a small number were taken near Deep Lake and a larger sample including ten species of fish were secured from the canal along the Tamiami Trail south of Naples. Fish were seined from Horst Creek, Joshua Creek and smaller tributaries in Hardee County. Twenty-one species of fish were secured as a result of this collecting trip. A few fish are included in this report of parasitism which came from areas outside the regions already mentioned. A small number of fish were taken from Silver Springs and Mr. Nelson Marshall furnished a few specimens belonging to four species of minnows taken from streams near Gainesville. In most of the locations where fish were collected the water was quiet or slow moving and usually choked with vegetation.

Almost all of the fish were preserved in formalin prior to examination. This hampered the identification of certain species of parasites, but as many fish were collected some distance from the laboratory it seemed the most practical means of handling the hosts. In this study special attention was paid to the helminth parasites. The Argulidae were identified by Dr. O. Lloyd Meehean of the Bureau of Fisheries, Welaka, Florida, while the remainder of the parasitic copepods were identified by Dr. Wilbur M. Tidd of the Department of Zoology and Entomology, Ohio State University. Gill flukes were submitted to Dr. John Mizelle of Oklahoma A. & M. College for identification to species. The report for those on the warmouth bass has already appeared (Mizelle and Seamster, 1939). Because of the numerous new species included the identifications of this group are

not completed. Carr's (1936) key was followed in the identification of fish.

In the comparison of parasitism by families of fish which follows, parasites are listed for each species in order of frequency of occurence. The number in parenthesis indicates the number of individuals carrying the designated parasite. The asterisk preceding the name of the parasite signifies immature stages.

LEPISOSTEIDAE

Lepisosteus platyrhincus De Kay—Florida Spotted Gar
Examined, 82. Parasitized, 77.

**Contracaecum spiculigerum* (Rud.) (64)
Macroderoides spiniferus Pearse (47)
**Agamonema* sp (10)
**Neascus vancleavei* (Agersborg) (9)
Argulus lepidostii Kellicott (9)
Proteocephalus singularis La Rue (3)
**Clinostomum marginatum* (Rud.) (2)
**Lernaea* sp. (2)
Dichelyne sp. (2)
**Camallanus* sp. (1)
**Eustrongylides* sp. (1)
Gyrodactylidae (1)
**Leptorhynchoides thecatus* (Linton) (1)

This species of predator fish was the most abundant of all of the larger forms encountered. In the Myakka River, certain of the Everglades canals and in other canals near Lake Okeechobee, from 500 to 2,000 gars weere taken in single hauls of the fifty foot seine. Specimens were examined for parasites from the following locations: twenty-seven from Englewood ditches, ten from the Myakka River, three from Horse Creek, fifteen from Lake Okeechobee and twenty-seven from the Everglades Canal near Naples. A majority of the gars from all locations carried *C. spiculigerum* and *M. spiniferus*, while gars from the Englewood region alone had *P. singularis*, *Camallanus* sp., *Dichelyne* and *L. thecatus*. Those from Englewood and Naples yielded *A. lepidostii* and *Agamonema* sp. *N. vancleavei* cysts were found in seven Englewood and three Lake Okeechobee gars. *C. marginatum* cysts were found in single hosts from Myakka and Lake Okeechobee.

AMIIDAE

Amia calva Linnaeus — Bowfin
Examined, 21. Parasitized, 21.

Macroderoides typicus (Winfield) (15)
Proteocephalus perplexus La Rue (14)

**Contracaecum spiculigerum* (Rud.) (9)
Macroderoides parvus (Hunter) (5)
Leptorhynchoides thecatus (Linton) (3)
Haplonema immutatum Ward and Magath (2)
Neoechinorhynchus cylindratus (Van Cleave) (1)
**Camallanus* sp. (1)
**Eustrongylides* sp. (1)
Haplobothrium globuliforme Cooper (1)
Argulus flavescens Wilson (1)
**Sebekia oxycephala* (Diesing) (1)
**Neascus* sp. (1)

Six, six, seven and two bowfins were taken from Englewood ponds, Myakka River, Lake Okeechobee and Horse Creek, respectively. From each of these location *P. perplexus* and *M. typicus* were obtained. *C. spiculigerum* was taken from bowfins in all locations except Lake Okeechobee. *M. parvus* and *L. thecatus* were secured in a few fish from Lake Okeechobee and Myakka River. *H. globuliforme* and *H. immutatum* were taken from a single bowfin from Lake Okeechobee. *A. flavescens, Camallanus* sp., *Eustrongylides* sp. and *S. oxycephala* were obtained from single Horse Creek bowfins. The other forms in the above list were taken only from the Myakka River bowfins.

CLUPEIDAE

Dorosoma cepedianum (LeSueur) — Northern Gizzard Shad
Examined, 7. Parasitized, 4.

Gyrodactylidae (4)
Flukes (1) (unidentified)

All of the gizzard shad were seined from the Myakka River.

CATOSTOMIDAE

Erimyson sucetta sucetta (Lacepede) Eastern Lake Chub-Sucker
Examined, 70. Parasitized, 66.

**Spiroxy* sp. (60)
Triganodistomum simeri Mueller and Van Cleave (8)
**Neascus* sp. (8)
Biacetabulum meridianum Hunter (5)
**Contracaecum spiculigerum* (Rud.) (5)
Ergasilus caeruleus Wilson (3)
Ergasilus megaceros (Wilson (2)
Octospinifer macilentus Van Cleave (2)
Argulus flavescens Wilson (2)
Dorylaimus sp. (2)
**Dichelyne* sp. (2)
**Neascus ambloplitis* Hughes (2)
Gyrodactylidae (1)
Capillaria Sp. (1)
Argulus maculosus Wilson (1)
Leptorhynchoides thecatus Linton (1)

Thirteen chub suckers were examined from Myakka River, thirteen from Englewood, seventeen from Lake Okeechobee, twenty-three from Horse and Joshua Creeks and four from the vicinity of Naples. *B. meridianum* was secured from two, one and two chub suckers from Myakka River, Lake Okeechobee and Naples, respectively. Six of these fish from Englewood and single specimens from Lake Okeechobee and Horse Creek yielded *T. simeri*. *E. megaceros, E. caeruleus* and *N. ambloplitis* were taken only from the Horse and Joshua Creek forms. The two species of *Argulus* came from Englewood chub suckers. According to Dr. Meehean the specimen of *A. maculosus* is a new record for Florida.

CYPRINIDAE

Notemigonus crysoleucas bosci Valenciennes—Florida golden shiner Examined, 43. Parasitized, 27.

**Neascus ambloplitis* Hughes (23)
**Agamonema* sp. (5)
Gyrodactylidae (5)
Plagiocirrus primus Van Cleave and Mueller (1)
**Camallanus* sp. (1)
Ergasilus megaceros Wilson (1)

Fourteen golden shiners from the Myakka River contained one form infected with a larval *Camallanus* sp. No other parasites were found in these fish. Twelve golden shiners from Englewood were examined and eight had cysts of *N. ambloplitis*, and one a species of gill fluke and a larval nematode. Seven hosts from Lake Okeechobee yielded three with *N. ambloplitis*, and one with a gill fluke. The remaining forms listed were taken from ten fish from Hardee County. All of these were infected with integumental *N. ambloplitis* cysts.

Notropis hypseopterus (Günther)—Big-finned shiner Examined, 3. Parasitized, 0.

These fish were collected from the Sante Fe River at Poe Springs, near High Springs.

Opsopoedus emiliae Hay—Pug-nosed minnow Examined, 25. Parasitized, 23.

Gyrodactylidae (9)
**Neascus vancleavei* (Agersborg) (9)
**Bucephalus* sp. (8)
**Agamonema* sp. (8)
**Dichelyne* sp. (2)
**Neascus ambloplitis* Hughes (1)
**Leptorhynchoides thecatus* (Linton) (1)

All of the pug-nosed minnows were taken from a small stream flowing into Joshua Creek near Arcadia. The larval *Bucephalus* sp. were taken from cysts in the livers of the minnows.

Notropis roseus Jordan—Coastal shiner
Examined, 6. Parasitized, 0.

These shiners were secured from Hogtown Creek near Gainesville by Nelson Marshall.

Erimystax harperi subterraneus
Examined, 6. Parasitized, 1.

**Agamonema* sp. (1)
These specimens were collected from Cow Sink, near Newberry.

Notropis chalybaeus (Cope)—Iron-colored shiner
Examined, 12. Parasitized, 0.

Six of these shiners were collected by Dr. C. F. Walker and Nelson Marshall from Hatchet Creek, near Gainesville. Six were secured from Hogtown Creek, near Gainesville by N. Marshall.

AMEIURIDAE

A total of 89 fish belonging to five species were examined from this family. All but two of these fish were parasitized. In the Lake Erie survey Bangham and Hunter (1939) found 73.3 per cent of 75 catfish of 7 species infected.

Ictalurus lacustris punctatus (Raf.)—Southern Channel Catfish
Examined, 13. Parasitized, 13.

Gyrodactylidae (13)
Alloglossidium corti (Lamont) (12)
Corallobothrium fimbriatum Essex (10)
**Contracaecum spiculigerum* (Rud.) (10)
Corallobothrium giganteum Essex (4)
**Clinostomum marginatum* (Rud.) (2)
Ergasilus elegans Wilson (2)
Argulus flavescens Wilson (2)
Capillaria catenata Van Cleave and Mueller (2)
**Proteocephalus* sp. (2)
Achtheres pimelodi Kryer (1)
Leptorhynchoides thecatus (Linton) (1)
Neoechinorhynchus cylindratus (Van Cleave) (1)

Seven channel catfish were examined from the Myakka River and six from Lake Okeechobee. The *A. flavescens* and *E. elegans* came from the latter fish, otherwise the forms were secured in about equal numbers from fish of the two locations.

Ictalurus catus (Linnaeus)—White Catfish
Examined, 8. Parasitized, 8.

**Contracaecum spiculigerum* (Rud.) (8)
Corallobothrium giganteum Essex (6)
Pomphorhynchus bulbocolli Linkins (1)
**Agamonema* sp. (1)
**Clinostomum marginatum* (Rud.) (1)
Gyrodactylidae (1)

All of the white catfish were taken in two collecting trips to the Myakka River.

Ameiurus nebulosus marmoratus (Holbrook)—Marbled Brown Bullhead
Examined, 22. Parasitized, 22.

Macroderoides spiniferus Pearse (11)
**Contracaecum spiculigerum* (Rud.) (10)
Gyrodactylidae (9)
Corallobothrium fimbriatum Essex (4)
**Agamonema* sp. (4)
Alloglossidium geminus (Mueller) (3)
Ergasilus versicolor Wilson (3)
Neoechinorhynchus cylindratus (Van Cleave) (2)
Argulus flavescens Wilson (2)
**Leptorhynchoides thecatus* (Linton) (1)
Dichelyne robusta (Van Cleave and Mueller) (1)
**Proteocephalus* sp. (1)

All of the *M. spiniferus, A. geminus* and *Proteocephalus* sp. came from Englewood brown bullheads. *C. spiculigerum, C. fimbriatum* and gill flukes were secured from the two bullheads from the Myakka River and two from Naples; those from the former also carried *N. cylindratus* and one from the latter region, *D. robusta.* The single specimen from Lake Okeechobee was found to have *C. spiculigerum, A. flavescens* and gill flukes.

Ameiurus natilis (Le Sueur)—Yellow Bullhead.
Examined, 45. Parasitized, 43.

**Contracaecum spiculigerum* (Rid.) (34)
Alloglossidium corti (Lamont) (25)
Gyrodactylidae (14)
**Proteocephalus* sp. (12)
Ergasilus versicolor Wilson (5)
Argulus flavescens Wilson (5)
Neoechinorhynchus cylindratus (Van Cleave) (5)
Alloglossidium geminus (Mueller) (3)
**Agamonema* sp. (5)
Dichelyne robusta (Van Cleave and Mueller) (3)
**Camallanus* sp. (2)
**Neascus vancleavei* (Agersborg) (2)
Crepidostomum ictaluri Surbar (2)
Allocreadium ictaluri Pearse (1)

Corallobothrium fimbriatum Essex (1)
Phyllodistomum staffordi Pearse (1)
**Paramphistomum stunkardi* Holl (1)
**Clinostomum marginatum* (Rud.) (1)
**Eustrongylides* sp. (1)
**Neoechinorhynchus* sp. (1)

About half of the yellow bullheads were taken in the vicinity of Englewood, thirteen from the Myakka River, six from Lake Okeechobee and five from Horse Creek. Van Cleave and Mueller (1934) report ten species as occasional parasites of yellow bullheads in Oneida Lake, New York. Seven of the species they list were also found in yellow bullheads from Florida. The three most abundant Florida species were taken from fish in each location. The remaining forms showed a scattered distribution with the exception that all of the *E. versicolor* came from the Horse Creek region.

Schilbeodes gyrinus (Mitchill)—Tadpole Madtom
Examined, 1. Parasitized (1).

Gyrodactylidae (1)
**Neascus* sp. (1)
**Contracaecum spiculigerum* (Rud.) (1)
**Agamonema* sp. (1)

This fish came from the Hardee County collection.

ESOCIDAE

Esox niger Le Sueur—Chain Pickerel
Examined, 10. Parasitized, 10.

**Contracaecum spiculigerum* (Rud.) (10)
Neoechinorhynchus cylindratus (Van Cleave) (5)
**Agamonema* sp. (3)
Macroderoides flavus Van Cleave and Mueller (2)
Protoecephalus pinguis La Rue (2)
**Neascus vancleavei* (Agersborg) (1)
**Clinostomum marginatum* (Rud.) (1)
Illinobdella sp. (1)

The chain pickerel was the only member of this family taken in the course of the survey and all specimens came from Lake Okeechobee.

CYPRINODONTIDAE

Ten species belonging to this family of small fishes were exceedingly numerous in the ditches and ponds about Englewood and the majority of the forms were collected from this area. Of the 232 fish collected comprising the cyrinodont fauna, 192 bore parasites, and most of these were immature stages. Several were not recognized

by the writer. One larval cestode with a rostellum bearing a circle of hooks was secured from mesentery cysts of members of this fish family. Certain larval nematodes and immature flukes were unidentified.

Fundulus similis (Baird and Girard)—Long-nosed Killifish
Examined, 24. Parasitized, 18.

**Leptorhinchoides thecatus* (Linton) (8)
**Agamonema* sp. (8)
Flukes (4)
**Neascus vancleavei* (Agersborg) (2)
**Contracaecum spiculigerum* (Rud.) (1)
**Cestode* (1)
**Proteocephalus* sp. (1)
**Neoechinorhynchus cylindratus* (Van Cleave) (1)

Two of the eight long-nosed killifish from a small pool near Horse Creek carried *Agamonema* sp. and *N. vancleavei;* one had the cestode cyst and another bore larval *L. thecatus* cysts. One specimen from the Myakka River carried a larval nematode within the intestine and a mesentery cyst with *C. spiculigerum.* The remaining fish of this species were taken at Silver Springs.

Fundulus seminolis Girard—Seminole Killifish
Examined, 14. Parasitized, 11.

**Neascus vancleavei* (Agersborg) (10)
Gyrodactylidae (5)
**Dorylaimus* sp. (5)
**Agamonema* sp. (3)
**Bothriocephalus* sp. (2)
*Fluke (1)

All of the Seminole killifish were secured from the same pond near Horse Creek where some of the previous fish species were taken.

Fundulus majalis (Walbaum)—Striped Killifish
Examined, 10. Parasitized, 10.

**Neascus vancleavei* (Agersborg) (10)
**Contracaecum spiculigerum* (Rud.) (3)
**Agamonema* sp. (2)
**Leptorhynchoides thecatus* (Linton) (1)
**Bothriocephalus* sp. (1)

Striped killifish were taken from ponds in the Englewood area.

Fundlus grandis Baird and Girard—Gulf Killifish
Examined, 8. Parasitized, 8.

**Neascus vancleavei* (Agersborg) (5)
**Agamonema* sp. (3)
**Bothriocephalus* sp. (2)
**Proteocephalus* sp. (1)
**Leptorhynchoides thecatus* (Linton) (1)

These fish were all taken in the Englewood area.

Fundulus chrysotus (Gunther)—Golden Topminnow
Examined, 84. Parasitized, 76.

**Agamonema* sp. (49)
**Neascus vancleavei* (Agersborg) (24)
**Contracaecum spiculigerum* (Rud.) (7)
Creptotrema funduli Mueller (7)
**Cestode* (5)
Ergasilus caeruleus Wilson (5)
**Proteocephalus* sp. (2)
**Leptorhynchoides thecatus* (Linton) (2)
Neoechinorhynchus sp. (1)
*Fluke (1)
Fluke (1)

Fifty-six golden topminnows from Englewood yielded forty-five with *Agamonema* sp., ten with *N. vancleavei* and one with *C. spiculigerum.* Two of four from Myakka carried *N. vancleavei* cysts. Nine golden topminnows were taken from a pond on the Englewood-Punta Gorda road just east of El Jobean. These fish carried the *C. funduli* and *E. caeruleus* listed above; two had *Agamonema* sp., and one a specimen of *Neoechinorhynchus* sp. The remaining golden topminnows were obtained from a pond near Lake Okeechobee.

Fundulus cingulatus (Valenciennes)—Banded Topminnow
Examined, 16. Parasitized, 12.

**Neascus vancleavei* (Agersborg) (7)
**Contracaecum spiculigerum* (Rud.) (5)
**Cestode* (5)
Neoechinorhynchus cylindratus (Van Cleave) (1)
**Agamonema* sp. (1)
*Fluke (1)
**Proteocephalus* sp. (1)

All of these banded topminnows came from a pond near Lake Okeechobee.

Fundulus notatus (Raf.)—Streaked Topminnow
Examined, 2. Parasitized, 2.

**Agamonema* sp. (2)

These two fish came from the El Jobean pond.

Jordanella floridae Goode and Bean—Flagfish
Examined, 70. Parasitized, 51.

**Agamonema* sp. (23)
**Contracaecum spiculigerum* (Rud.) (17)
*Cestode (8)
**Neascus* sp. (7)
**Neascus vancleavei* (Agersborg) (5)
Ergasilus sp. (5)
Neoechinorhynchus sp. (3)
Neoechinorhynchus cylindratus (Van Cleave) (1)
Paramphistomum stunkardi Holl (1)
Fluke (1)
**Proteocephalus* sp. (1)

Three flagfish from Horse Creek were without parasites. Nine from the Myakka River had two with *C. spiculigerum,* three with *Agemonema* sp., two with *N. vincleavei* and one with *Neascus* sp. Ten flagfish from near Lake Okeechobee yielded seven with the larval cestode having the hooked rostellum, one with an encysted *Proteocephalus* sp., one with a larval nematode. The remaining flagfish came from the Englewood area.

Floridichthys carpio carpio (Günther)—Florida Gold-spotted Killifish

Examined, 3. Parasitized, 2.

Argulus flavescens Wilson (1)
Ergasilus sp. (1)
Fluke (1)

These fish came from the El Jobean pond.

Cyprinodon variegatus variegatus Lacépéde—Southern Sheepshead Killifish

Examined, 6. Parasitized, 2.

**Agamonema* sp. (1)
**Neascus* sp. (1)

These killifish came from the El Jobean pond.

POECILIIDAE

Heterandria formosa (Agassiz)—Least Killifish

Examined, 21. Parasitized, 10.

**Neascus vancleavei* (Agersborg) (3)
**Proteocephalus* sp. (3)
*Fluke (2)
**Neoechinorhynchus cylindratus* (Van Cleave) (1)
**Contracaecum spiculigerum* (Rud.) (1)
**Eustrongylides* sp. (1)
Fluke (1)

One of the four least killifish from Englewood contained ancysted *N. cylindratus.* Three of five from El Jobean had cysts of *Proteocephalus* sp., while three of five from Horse Creek yielded the three *N. vancleavei* and the *Eustrongylides* sp. The three remaining parasites listed came from seven least killifish examined from Silver Springs.

Mollienisia latipinno Le Sueur—Sailfin

Examined, 93. Parasitized, 79.

**Neascus vancleavei* (Agersborg) (53)
**Neascus* sp. (23)
Gyrodactylidae (18)
Ergasilus sp. (8)
**Agamonema* sp. (4)
**Contracaecum spiculigerum* (Rud.) (3)
**Clinostomum marginatum* (Rud.) (3)
Fluke (1)

Seven of eight flagfish from the Myakka River had only *N. vancleavei* cysts. Sixteen flagfish were examined from Horse Creek and the following parasites were encountered: eight with *N. vancleavei;* three with *Neascus* sp.; four with gill flukes; and one with *C. spiculigerum.* Eleven flagfish from Silver Springs had two carrying *C. spiculigerum* and *Agamonema* sp., one with gill flukes and one with *C. marginatum.* All of the remaining infected flagfish came from the fifty-eight examined near Englewood.

Gambusia affinis holbrookii (Gerard)—Eastern Mosquito-fish
Examined, 79. Parasitized, 61.

**Neascus vancleavi* (Agersborg) (44)
**Agamonema* sp. (25)
Acanthocephala (11)
Fluke (5)
**Neascus* sp. (4)
Ergasilus sp. (3)
*Cestode (3)
**Leptorhinchoides thecatus* (Linton) (3)
**Contracaecum spiculigerum* (Rud.) (2)
**Bothriocephalus* sp. (1)
**Sebekia oxycephala* (Diesing) (1)
**Lernaea* sp. (1)
**Neoechinorhynchus* sp. (1)

Fourteen of twenty mosquito-fish from Silver Springs were free of parasites. Five of those remaining had unidentified intestinal flukes, two carried larval nimatodes, one an encysted *L. thecatus.* Eleven of twenty mosquito-fish from El Jobean had an unidentified acanthocephan form, four had *N. vancleavei,* five larval nematodes, two *L. thecatus* cysts, and one an encysted *Neochinorhynchus* sp. Another mosquito-fish from El Jobean carried an encysted linguatulid parasite, *S. oxycephala.* This larval form lives as an adult in the lungs, trachea and pharynx of alligators. The larval stage of this parasite was taken from the bowfin, warmouth bass, stump-knocker, black-spotted sunfish and black crappie during the Florida survey. *S. oxycephala* is discussed in a report now in press, (Bangham and Venard). All of eleven mosquito-fish from Horse Creek carried *N. vancleavei,* two had *Neascus* sp. and three yielded the same encysted cestode found in other related fish. The remaining listed forms were secured from the Englewood mosquito-fish.

SERRANIDAE

Centropomus undecimalis (Bloch)—Northern Robalo (Snook)
Examined, 4. Parasitized, 4.

**Contracaecum spiculigerum* (Rud.) (3)
Gyrodactylidae (2)
Fluke (2)

Neoechinorhynchus cylindratus (Van Cleave) (2)
**Neascus* sp. (1)
**Agamonema* sp. (1)
Ergasilus sp. (1)

The robalo is one of those marine fish are often found to ascend fresh-water streams. Two of these fish were taken at Myakka River and two at a location in the Everglades Canal, four miles north of Everglades City. The robalo from Myakka had two fish with *C. spiculigerum* and one with gill flukes and *N. cylindratus*.

ELASSEMIDAE

Elassoma evergladei Jordan—Everglades Pigmy Sunfish
Examined, 1. Parasitized, 1.

**Neascus ps.* AVQ
**Agamonema* sp. (1)
**Proteocephalus* sp. (1)

This pigmy sunfish came from a pond in the Englewood region.

ATHERINIDAE

Menidia beryllina atrimentis Kendall—Freshwater Glass-minnow
Examined, 10. Parasitized, 5.

**Bucephalus* sp. (3)
Fluke (3)
**Neascus* sp. (1)

These fish were taken at the El Jobean pond.

Labidesthes sicculus vanhyningi Bean and Reid—Florida Brook Silversides
Examined, 17. Parasitized, 16.

Creptotrema funduli Mueller (13)
**Neascus vancleavei* (Agersborg) (5)
**Agamonema* sp. (4)
**Bothriocephalus* sp. (2)
**Neascus ambloplitis* Hughes (2)
**Contracaecum spiculigerum* (Rud.) (1)
Paramphistomum stunkardi Holl (1)

The brook silversides came from a small stream flowing into Joshua Creek in Hardee County.

MUGILIDAE

Mugil cephalus Linnaeus — Striped Mullet
Examined, 6. Parasitized, 6.

**Agamonema* sp. (3)
Bomolochus sp. (2)
Gyrodactylidae (2)
Microcotyle sp. (1)
Fluke (1)

These fish were taken in the pond below El Jobean.

ELEOTRIDAE

Dormitator maculatus (Bloch) — Fat Sleeper
Examined, 14. Parasitized, 10.

**Agamonema* sp. (7)
**Contracaecum spiculigerum* (Rud.) (4)
**Paramphistomum stunkardi* Holl (1)
*Fluke (1)
**Neascus* sp. (1)
*Acanthocephala (1)

Fat sleepers were taken from three ponds in the Englewood area.

ARCHIRIDAE

Trinectus maculatus (Rafinesque) — Northern Round Sole
Examined, 4. Parasitized, 0.

GERRIDAE

Eucinostomus gula (Cuvier and Valenciennes) — Silver Jenny
Examined, 13. Parasitized, 5.

Gyrodactylidae (3)
**Neascus* sp. (1)
Fluke (1)

All of these fish came from the El Jobean pool.

CHECK LIST OF PARASITES AND THEIR FISH HOSTS

The parasites of the members of the family Centrarchidae are included in the following list which gives the host-parasite relationships of the Florida forms. Many of these species are able to infect a large number of different fish. This is especially true of the larval stages of the parasites.

TREMATODA

Urocleidus grandis Mizelle and Seamster — Warmouth bass
Urocelidus chaenobryttus Mizelle and Seamster — Warmouth bass
Actinocleidus okeechobeensis Mizelle and Seamster — Warmouth bass
Actinocleidus flagellatus Mizelle and Seamster — Warmouth bass
Gyrodactylidae (unidentified) — Spotted gar, Gizzard shad, Chub sucker, Golden shiner, Pug-nosed minnow, Channel catfish, White catfish, Brown bullhead, Yellow bullhead, Tadpole madtom, Seminole killifish, Sailfin, Robalo, Large-mouthed bass, Stump-knocker, Bluegil, Black crappie, Black-spotted sunfish, Florida long-eared Bluegill, Black crappie, Black-spotted sunfish, Florida long-eared sunfish, Silver jenny, Striped mullet.
Microcotyle sp. — Striped mullet
Bucephalus sp. — Glass minnow, Pug-nosed minnow

Paramphistomum stunkardi Holl — Yellow bullhead, Flagfish Florida brook, silversides, Black crappie, Warmouth bass, Bluegill, Stump-knocker, Black-spotted sunfish, Large-mouthed black bass, Fat sleeper.

Phyllodistomum staffordi Pearse — Yellow bullhead

Allocreadium ictaluri Pearse — Yellow bullhead

Anallocreadium sp. — Warmouth bass, Bluegill, Black-spotted sunfish, Stump-knocker

Crepidostomum cornutum (Osborn) — Warmouth bass, Large-mouthed black bass.

Crepidostomum sp. — Black crappie

Crepidostomum ictaluri (Surber) — Yellow bullhead

Plagiocirrus primus Van Cleave and Mueller — Florida golden shiner

Creptotrema funduli Mueller — Florida brook silversides, Golden topminnow

Triganodistomum simeri Mueller and Van Cleave — Chub sucker

Macroderoides spiniferus Pearse — Spotted gar, Marbled brown bullhead

Macroderoides typicus (Winfield) — Bowfin

Macroderoides parvus (Hunter) — Bowfin

Macroderoides flavus Van Cleave and Mueller — Chain pickerel

Alloglossidium corti (Lamont)—Channel catfish. Yellow bullhead, Stump-knocker, Warmouth bass

Alloglossidium geminus (Mueller) — Marbled brown bullhead, Yellow bullhead

Clinostomum marginatum (Rudolphi) — Spotted gar, Channel catfish, White catfish, Yellow bullhead, Chain pickerel, Sailfin, Large-mouthed black bass, Warmouth bass, Bluegill, Stump-knocker

Neascus vancleavei (Agersborg) — Spotted gar, Pug-nosed minnow, Yellow bullhead, Chain pickerel, Long-nosed killifish, Seminole killifish, Stripped killifish, Gulf killifish, Golden topminnow, Banded topminnow, Flagfish, Least killifish, Mosquito-fish, Florida brook silversides, Large-mouthed black bass, Warmouth bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sunfish, Blue-spotted sunfish, Florida long-eared sunfish.

Neascus ambloplitis Hughes — Chub sucker, Florida golden shiner, Pug-nosed minnow, Florida brook silversides, Large-mouthed black bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sunfish

Neascus sp. — Bowfin, Chub sucker, Tadpole madtom, Flagfish, Southern sheepshead killifish, Sailfin, Mosquito-fish, Robalo, Everglades pigmy sunfish, Freshwater glass minnow, Fat sleeper

Fluke (mature, unidentified) — Gizzard shad, Long-nosed killifish, Golden topminnow, Banded topminnow, Least killifish, Sailfin, Warmouth bass, Stump-knocker, Black-spotted sunfish, Fat sleeper.

CESTODA

Biacetabulum meridianum Hunter — Lake chub sucker

Bothriocephalus claviceps (Goeze) — Large-mouthed black bass

Bothriocephalus sp. (larval) — Seminole killifish, Striped killifish, Gulf killifish, Mosquito-fish, Florida brook silversides, Large-mouthed black bass, Warmouth bass, Bluegill, Black-spotted sunfish

Haplobothrium globuliforme Cooper — Bowfin

Proteocephalus pinguis La Rue — Chain pickerel

Protoecephalus perplexus La Rue — Bowfin

Proteocephalus singularis La Rue — Spotted gar

Proteocephalus sp. (larval cysts) — Channel catfish, Brown bullhead, Yellow bullhead, Long-nosed killifish, Gulf killifish, Golden topminnow, Banded topminnow, Flagfish, Least killifish, Everglades pigmy sunfish, Large-mouthed black bass, Warmouth bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sunfish, Blue-spotted sunfish

Corallobothrium fimbriatum Essex — Channel catfish, Brown bullhead, Yellow bullhead

Corallobothrium giganteum Essex — Channel catfish, White catfish

Cestode (larval, encysted form with hooked rostellum and heavy integument) — Long-nosed killifish, Banded topminnow, Golden topminnow, Flagfish, Mosquito-fish

NEMATODA

Capillaria catenata Van Cleave and Mueller — Channel catfish

Capillaria sp. — Chub sucker, Stump-knocker

Contracaecum spiculigerum (Rud.) — Spotted gar, Bowfin, Chub sucker, Channel catfish, White catfish, Brown bullhead, Yellow bullhead, Tadpole madtom, Chain pickerel, Long-nosed killifish, Striped killifish, Golden topminnow, Banded topminnow, Flagfish, Least killifish, Sailfin, Mosquito-fish, Robalo, Florida brook silversides, Large-mouthed black bass, Warmouth bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sunfish, Blue spotted sunfish, Florida long-eared sunfish, Fat sleeper

Spinitectus carolini Holl — Large-mouthed black bass, Bluegill

Camallanus oxycephalus Ward and Magath — Warmouth bass, Bluegill

Camallanus sp. (larval) — Spotted gar, Bowfin, Golden shiner, Yellow bullhead, Large-mouthed black bass, Warmouth bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sunfish

Dichelyne cotylophora (Ward and Magath) — Bluegill

Dichelyne robusta (Van Cleave and Mueller)—Marbled brown bullhead, Yellow bullhead

Dichelyne sp. — Spotted gar, Chub sucker, Large-mouthed black bass, Warmouth bass, Stump-knocker

Haplonema immutatum Ward and Magath — Bowfin

Philometra cylindracea (Ward and Magath) — Bluegill

Spiroxys sp. — Chub sucker

Eustrongylides sp. — Spotted gar, Bowfin, Yellow bullhead, Least killifish, Large-mouthed black bass, Warmouth bass, Bluegill

Agamonema sp. — Spotted gar, Florida golden shiner, Pug-nosed minnow, *Erimystax harperi subkwaneus,* White catfish, Marbled brown bullhead, Yellow bullhead, Tadpole madtom, Chain pickerel, Long-nosed killifish, Seminole killifish, Striped killifish, Gulf killifish, Golden topminnow, Banded topminnow, Streaked topminnow, Flagfish, Southern sheepshead killifish, Sailfin, Mosquito-fish, Robalo, Everglades pigmy sunfish, Florida brook silversides, Large-mouthed black bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sunfish, Blue-spotted sunfish, Florida long-eared sunfish, Striped mullet, Fat sleeper

Dorylaimus sp. — Chub sucker, Seminole killifish

ACANTHOCEPHALA

Neoechinorhynchus cylindratus (Van Cleave)—Bowfin, Channel catfish, Brown bullhead, Yellow bullhead, Chain pickerel, Long-nosed killifish, Banded topminnow, Flagfish, Least killifish, Robalo, Large-mouthed black bass, Warmouth bass, Bluegill, Black crappie, Stump-knocker, Black-spotted sun-fish

Neoechinorhynchus sp. — Yellow bullhead, Golden topminnow, Flagfish, Mosquito-fish

Octospinifer macilentus Van Cleave — Chub sucker

Leptorhynchoides thecatus (Linton) — Spotted gar, Bowfin, Chub sucker, Pug-nosed minnow, Channel catfish, Brown bullhead, Long-nosed killifish, Striped killifish, Gulf killifish, Golden topminnow, Mosquito-fish, Large-mouthed black bass, Warmouth bass, Bluegill, Black crappie, Stump-knocker, Black spotted sunfish, Blue-spotted sunfish, Florida long-eared sunfish.

Pomphorhynchus bulbocolli Linkins — White catfish

Acanthocephala (Unidentified) — Mosquito-fish, Fat sleeper

PARASITIC COPEPODS

Argulus flavescens Wilson — Bowfin, Chub sucker, Channel catfish, Yellow bullhead, Florida gold-spotted killifish, Large-mouthed black bass, Warmouth bass, Stump-knocker

Argulus lepidostei Kellicott — Spotted gar

Argulus maculosus Wilson—Chub sucker

Achtheres micropteri Wright—Warmouth bass

Achtheres pimelodi Kroyer—Channel catfish

Ergasilus caeruleus Wilson — Chub sucker, Golden topminnow, Large-mouthed black bass, Warmouth bass, Bluegill, Stumpknocker, Black-spotted sunfish

Ergasilus megaceros Wilson — Chub sucker, Florida golden shiner

Ergasilus elegans Wilson — Channel catfish.

Ergasilus versicolor Wilson — Marbled brown bullhead, Yellow bullhead

Ergasilus centrarchidarum Wright — Large-mouthed black bass

Ergasilus sp. — Flagfish, Florida gold-spotted killifish, Sailfin, Mosquito-fish

Bomolochus sp. — Striped mullet

Lernaea sp. — Spotted gar, Mosquito-fish, Large-mouthed black bass.

LINGAUTULIDAE

Sebekia oxycephala (Diesing) — Bowfin, Mosquito-fish, Warmouth bass, Black crappie, Stump-knocker, Black-spotted sunfish, Florida long-eared sunfish.

HIRUDINEA

Illinobdella sp. — Chain pickerel, Large-mouthed black bass, Warmouth bass, Bluegill, Stump-knocker, Black-spotted sunfish.

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A PRELIMINARY LIST OF FLORIDA HEPATICS

James B. McFarlin
Florida Botanical Gardens & Arboretum
Sebring, Florida

The following list of the hepatic flora of Florida is based largely upon the numerous collections made by the author. Much additional information has been gained from herbarium records, especially those found at Duke University, which were kindly communicated to the writer through the courtesy of Dr. D. C. Correll and Dr. H. L. Blomquist. Supplementing the field and herbarium work a thorough search has revealed many records scattered through the botanical literature of the past quarter century.

Most noteworthy are the numerous papers of Dr. Alexander W. Evans in which are found many of the original records of Florida hepatics. A list of liverworts collected by Mr. Severin Rapp, mainly in the vicinity of Sanford, in Seminole County, was published in the Bryologist in 1915 by Miss Caroline C. Haynes. A more recent paper, "Liverworts of North and Central Florida," by Dr. Herman Kurz and Mr. Thomas Little, was published by the Florida State College for Women at Tallahassee in 1933. This last paper deals for the most part with the region about Marianna, Jackson County; Bristol, Liberty County; and Gainesville in Alachua County. The information contained in these papers has been freely drawn upon.

Furthermore, it should be noted that this paper is not merely a list of Florida's hepatic flora, but that the author has attempted to suggest the trend of distribution of the species found within our range, by listing under each species the counties in which it is known to occur. For convenience this county distribution has been arranged alphabetically. It will be noted that in some cases the stations are widely separated, this should not be interpreted as indicating that the species does not occur elsewhere in our state, but rather that it has not been definitely recorded from the intermediate localities at the present time, and that further collecting is necessary to definitely outline the range of the species in Florida. The present paper lists a total of 136 species and 5 varieties divided among 51 genera, which are now known to occur in Florida.

In closing, the author wishes to acknowledge his indebtedness to Dr. Lois Clark for making the determinations of the writer's collec-

tions cited in this paper. Furthermore, he also wishes to express his appreciation for the many pleasant hours spent in the field with Dr. A. J. Grout; for his encouragement, criticisms, and many helpful suggestions.

Note: The thalloid hepatics are arranged according to Frye and Clark as set forth in the "Hepaticæ of North America," Univ. Washington Publ. Biol. *6* (1): 1-62, 1937., while the arrangement of the foliose species follows the arrangement as set forth by Dr. Alexander W. Evans, "A List of Hepaticæ Found in the United States, Canada, and Arctic America," Bryologist *43*: 133-138, 1940.

SPHAEROCARPACAE

SPHAEROCARPUS (Micheli) Boehm. Ludwig. Def. Gen. Pl., Ed. 2, 501, 1760.

Sphaerocarpos Micheli Nov. Pl. Gen. **4** pl. 3, 1729.
Symphoricarpus Adans. Fam. Pl. **2**: 14, 1763.

Sphaerocarpus Donnellii Aust., Bull. Torr. Bot. Club **6**: 157, 1877.

ALACHUA COUNTY: Little: Payne's Prairie 4 miles south of Gainesville.
CITRUS COUNTY: McFarlin, 226, and 243: In an old field near Pineola.
DUVAL COUNTY: J. Donnell Smith: Near Jacksonville, in 1877.
JEFFERSON COUNTY: Schornherst: Recorded without definite locality.
LEON COUNTY: Kurz: At Silver Lake about 3 miles south of Tallahassee.
POLK COUNTY: McFarlin, 359: Near Fort Meade, and 380: In the flatwoods east of Brewster.
SEMINOLE COUNTY: S. Rapp, 17: In an old field, Sanford. Specimen in the Duke University herbarium.

Sphaerocarpus texanus Aust. Bull. Torr. Bot. Club 6: 158, 1877.

ALACHUA COUNTY: Little: Payne's Prairie, 4 miles south of Gainesville
HIGHLANDS COUNTY: McFarlin, 1291: In Highlands Hammock State Park near Sebring.
LEON COUNTY: Kurz: In a corn field about 3 miles from Tallahassee, along the Quincy road.
MANATEE COUNTY: A. J. Grout: Reported as common about Manatee.
SEMINOLE COUNTY: S. Rapp, 21: Along walks mixed with *Riccia crystallina* L., and in old fields, Sanford. Specimen in the herbarium of Duke University.

RICCIACEAE

RICCIA L. Sp. Pl. 1138, 1753.

Ricciella A. Br., Flora **4**: 756. 1821.
Cryptocarpus Aust., Proc. Acad. Nat. Sci. **21** (1869): 231, 1870.
Thallocarpus Lindb. Not. Saellsk. Fauna, et Fl. Fennica **13**: 377, 1874.
Angiocarpus Trev. Mem. Istit. Lomb. **13**: 444, 1877.

Riccia beyrichiana Hampe, Lehm. Stirp, Pugill. 7: 1. 1838.

ALACHUA COUNTY: Little: On the campus at Gainesville, and by a pond about 3 miles west of that city.
UNRECORDED COUNTIES: In 1884 L. M. Underwood records this species from cultivated fields and rocky ground, in the Hepaticae of North America. In 1917, Marshall A. Howe, in a paper, "Notes on North American Species of Riccia" credits this species to Florida.

Riccia crystallina L. Sp. Pl. 1138. 1753.

ALACHUA COUNTY: Little: About a pond 3 miles west of Gainesville.
MANATEE COUNTY: Grout: Muddy shores of small pond east of Oneco.
SEMINOLE COUNTY: S. Rapp: On sidewalks between bricks, Sanford, April 6, 1912. In the herbarium of Duke University.

Riccia Curtisii James, Aust., in Proc. Acad. Nat. Sci. **21** (1869): 231, as synonym.

ALACHUA COUNTY: Little: Along Hatchet Creek about eight miles east of Gainesville.
HIGHLANDS COUNTY: McFarlin, 1288; and 1337: In Highland Hammock State Park near Sebring, and 1924: In Vaughn's hammock near Crewville.
LEON COUNTY: Kurz: Silver Lake about three miles south of Tallahassee.
POLK COUNTY: McFarlin, 318: In a hammock about six miles west of Lakeland, and 267: About two miles northeast of Homeland.
SEMINOLE COUNTY: S. Rapp, 12: On rich soil in ditches, Sanford. Specimen in the herbarium of Duke University.

Riccia Donnellii Aust., Bull. Torr. Bot. Club **6**: 157, 1877.

ALACHUA COUNTY: Little: About a pond three miles west of Gainesville.
DUVAL COUNTY: J. Donnell Smith: Near Jacksonville in 1877 (type coll.).
HARDEE COUNTY: McFarlin, 1239: On ditch banks near Zolfo, October 1, 1934.
HIGHLAND COUNTY: 10282: On moist sand in the flatwoods at the Florida Botanical Gardens near Sebring.
POLK COUNTY: McFarlin, 27: On moist ground in the flatwoods near Winter Haven.
SEMINOLE COUNTY: S. Rapp, 9: On sandy ditch banks, Sanford. Specimen in the Duke Universtiy herbarium.
UNRECORDED COUNTIES: L. M. Underwood records this species as being collected by J. Donnell Smith from gardens and cattle ranges.

Riccia fluitans L. Sp. Pl. 1139, 1753.

ALACHUA COUNTY: Recorded by William A. Murrill in a preliminary check list of Bryophytes of Alachua County.
CITRUS COUNTY: H. L. Blomquist, 8884: Floating on water in the fern grottoes near Pineola. Specimen in the Duke University herbarium. McFarlin, 234: In the Withlacoochee River near Pineola.
COLLIER COUNTY: McFarlin, 1564: In a Pop Ash swamp in Billey-Kissimmee Swamp about twenty miles east of Immokalee.
HIGHLANDS COUNTY: McFarlin, 1392: In pots at the nursery of the Florida Botanical Garden near Sebring.
LEON COUNTY: Kurz, records this species in his paper on "Liverworts of North and Central Florida" without definite locality, as "common all over our region."
MANATEE COUNTY: McFarlin, 412: In low swamp places. A. J. Grout reports this species as frequent.
POLK COUNTY: McFarlin, 23: Common in Saddle Creek swamp near Bartow, and 545: In a low hammock east of Hesperides, also 578: In a swamp near Kathleen.
SEMINOLE COUNTY: S. Rapp, 4: Common in wet ditches and creeks, Sanford. Specimen in the Duke University herbarium.

Riccia sorocarpa Bisch., Nova Acta Acad. Caes. Leop.-Carol, Nat. Cur. **17**: 1053, *pl.*71,*f.*11, 1835.

LEON COUNTY: Kurz: About 3 miles from Tallahassee along the Quincy road.

Riccia Sullivantii Aust., Proc. Acad. Nat. Sci. **21** (1869): 233. 1870.

LEON COUNTY: Kurz: At Silver Lake about 3 miles south of Tallahassee.
POLK COUNTY: McFarlin, 267: About 2 miles northeast of Homeland.
SEMINOLE COUNTY: S. Rapp, 58: In a ditch, January 1916 at Sanford. Specimen in the herbarium of Duke University.

RICCIOCARPUS Corda, Opiz. Beitr. 651, 1829.

Ricciocarpus natans (L.) Corda, Opiz. Beitr. 651. 1829.

ALACHUA COUNTY: Recorded in "A Check List of Hepatics of Alachua County" by W. A. Murrill.
LEON COUNTY: Kurz and Little: Recorded in "Liverworts of North and Central Florida" as more or less common in ponds in North Florida.
SEMINOLE COUNTY: S. Rapp, 8: On the sides of ditches, Sanford.
UNRECORDED COUNTIES: Reported by L. M. Underwood, as occurring in exsicated pools and ditches in Florida.

REBOULIACEAE

REBOULIA G. L. & N. Syn. Hep. 547, 1846.

Asterella Beauv., Lam. Encycl. Meth. Suppl. **1**: 502, 1810, in part.
Rebouillia Raddi, Opusc. Sci. Bologna **2**: 357, 1818.
Strozzia S. F. Gray, Nat. Arr. Brit. Pl. **1**: 682, 1821
Rhakiocarpon Corda, Opiz. Beitr. 648. 1829.
Achiton Corda, Opiz. Beitr. 649. 1829.
Otiona Corda, Opiz. Beitr. 649, 1829.

Reboulia hemisphaerica (L.) Raddi in Opusc. scient. di Bologna **2**: 357, 1818.

GADSDEN COUNTY: Kurz & Little: Aspalaga.
JACKSON COUNTY: McFarlin, 1404 and 1405: On limestone outcrops at Caverns near Marianna.
LEON COUNTY: Kurz: Along ditch on college farm, Tallahassee.
SEMINOLE COUNTY: S. Rapp, 88: Sanford.
VOLUSIA COUNTY: H. L. Blomquist: On moist rocks, New Smyrna. Specimen in the herbarium of Duke University.

MARCHANTIACEAE

CONOCEPHALUM Wiggers, Prim. Fl. Holsat. 82. 1780.

Fegatella Raddi, Opusc. Sci. Bologna **2**: 356, 1818.

Conocephalum conicum (L.) Wiggers Prim. Fl. Holsat. 82, 1780.

JACKSON COUNTY: Kurz: On limestone cliffs along the Chipola River at Marianna. McFarlin, 1403, 1406 and 1413: On rocky limestone outcrops at caverns near Marianna.

DUMORTIERA Reinw. Bl. & Nees, Nova Acta Acad. Caes. Leop.-Carol. Nat. Cur. **7**: 410, 1812.

Hygropyla Tayl., Trans. Linn. Soc. **17**: 390 *pl.* 15, 1835.
Hygrophila Tayl., Mackay Fl. Hibern. **2**: 53, 1836.
Askepos Griffith Not Pl. Asiat. **2**: 340, 1849.

Dumortiera hirsuta (Sw.) Reinw. Bl. & Nees, Nova Acta Acad. Caes. Leop.-Carol. Nat. Cur. **12**: 410. 1812.

ALACHUA COUNTY: Little: South of the Athletic field, Gainesville; also at the Devil's Millhopper about six miles northwest of Gainesville. H. L. Bloomquist, 8810: Devil's Millhopper. Specimen in the herbarium of Duke University.

CALHOUN COUNTY: D. S. Correll, 8576: On a wet limestone ledge near Aspalaga along the Apalachicola River.

CITRUS COUNTY: McFarlin, 231: On rocky limestone walls of the fern grottoes near Pineola.

JACKSON COUNTY: McFarlin. 1393: On limestone outcrops at the caverns north of Marianna.

LEON COUNTY: Kurz: About four miles from Tallahassee along the road to Quincy.

Dumortiera hirsuta (Sw.) Reinw. var. **nepalensis** (Tayl.) Frye & Clark. Univ. Wash. Publ. **6**[1]: 93, 1937.

ALACHUA COUNTY: R. M. Harper, 13: Gainesville and vicinity. N. L. T. Nelson, 100: from the same locality.

CITRUS COUNTY: Dr. J. K. Small: Pineola.

MARCHANTIA L. Sp. Pl. 1137, 1753.

Chlamidium Corda, Opiz. Beitr. 647, 1829.

Marchantia domingensis Lehm. & Lindenb., Lehm. Stirp. Pugil. **6**: 22, 1834.

ALACHUA COUNTY: H. L. Blomquist, 8866: On moist soil, south side of the Devil's Millhopper about 6 miles northwest of Gainesville. D. S. Correll, 8580: On moist dirt on limestone rocks in the Devil's Millhopper, also D. S. & H. B. Correll, 8906; same locality. Little, (without no.) Devil's Millhopper.

CALHOUN COUNTY: D. S. Correll, 8579: On a wet limestone ledge along the Apalachicola River near Aspalaga. Specimen in the herbarium of Duke University.

GADSDEN COUNTY: Kurz: Aspalaga.

Marchantia polymorpha L. Sp. Pl. 1137, 1753.

LEON COUNTY: Kurz: About 10 miles east of Tallahassee.

SEMINLE COUNTY: S. Rapp, 7: On grounds and on bricks, Sanford.

RICCARDIACEAE

METZGERIA Raddi, Mem. Soc. Ital. Sci. Modena **18**: 45, 1818.

Jungermannia L., Sp. Pl., Ed. 1, 1136, 1753, in part.
Rhizophyllum Beauv., Fl. d'Ow. Ben. **1**: 21, 1804, in part.
Papa S. F. Gray, Nat. Arr. Brit. Pl. **1**: 679, 1821.
Hervera S. F. Gray, Nat. Arr. Brit. Pl. **1**: 685, 1821.
Fasciola Dum., Comm. Bot. 114, 1822.
Echinogyna Dum., Sylloge Jung. Eur. 83, 1831.
Echinomitrium Corda, Sturm Deutschl. Fl. **2**: 77, 1832.

Metzgeria ciliifera Schweinitz Musc. Hep. Amer. Sept. 20, 1821.

ALACHUA COUNTY: Little: Along run at northern edge of Gainesville. H. L. Blomquist, 8874: On base of trees, Devil's Millhopper about 6 miles northwest of Gainesville.

LEON COUNTY: Kurz: About 3 miles from Tallahassee, along the Quincy road.

SEMINOLE COUNTY: S. Rapp, 29: On bark and exposed roots of *Magnolia grandiflora,* in a high hammock near Sanford. Specimen in the herbarium of Duke University.

Metzgeria uncigera Evans Ann. Bot. **24**: 276, *figs. 1-3,* 1910.

ESCAMBIA COUNTY: McFarlin, 1250 and 1542: In a low hammock along the Escambia River.

GADSDEN COUNTY: Kurz and Little: In a ravine on the trunk of Magnolia near the Apalachicola River, Aspalaga.

HOLMES COUNTY: McFarlin, 1512 and 1516: In a low hammock along Holmes Creek near Bonifay.

POLK COUNTY: McFarlin, 1736 and 1737: On the bark of *Magnolia grandiflora*, in a high hammock near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 73: On the trunk of trees at Robinson Springs, eight miles south of Sanford.

PALLAVICINIA S. F. Gray, Nat. Arr. Brit. Pl. **1**: 775, 1821.

Dilaena Dum. Comm. Bot. 114, 1822.

Diplomitrion Corda, Opiz. Beitr. **1**: 653, 1829.

Diplolaena Dum., Syll. Jung. 82, *pl. 2, fig.* 21, 1831. Not of R. Br. 1814.

Gymnomitrion Hueben. Hep. Germ. 45, 1834. Not of Corda, Opiz. Beitr. **1**: 651, 1830.

Symphyogyna Mont. & Nees, Ann. Sci. Nat., Ser. 2, **5**: 66, 1836.

Blyttia Endl. Gen. Pl. 1339, 1839. Not of Arnott. 1838; not of Fries, 1839.

Hollia Endl. Gen. Pl. Suppl. **2**: 103, 1842. Not of Sieber. 1836.

Steetzia Lehm., Plantae Preissianae **2**: 129, 1846.

Systasis Griffith, Notulae ad Plantas Asiaticus, - 2. On the higher Cryptogamous plants. 1849. Calcutta.

Mittenia Gottsche, Triana et Planchon in Ann. Sci. Nat., Ser. 5, **1**: 77, 1864. Not of Lindb., 1863.

Pallavicinia Lindb., Not. Sællsk. Fennica **9**: 14, 1868.

Pallavicinia Lyellii (Hook.) S. F. Gray, Nat. Arr. Brit. Pl. **1**: 755, 1821.

ALACHUA COUNTY: Recorded in "Bryophytes of Alachua County" by W. A. Murrill, without definite locality.

ESCAMBIA COUNTY: McFarlan, 1449: In a low hammock along the Escambia River.

HIGHLANDS COUNTY: D. S. Correll, 8578: On rotten logs and mud in a swamp about 5 miles east of Childs, also McFarlin, 310; 1100; and 1292: In Highlands Hammock State Park near Sebring.

HOLMES COUNTY: McFarlin, 1513: In a low hammock along Holmes Creek near Bonifay.

LEON COUNTY: Kurz: Listed in "Liverworts of North and Central Florida" as common throughout Florida.

LIERTY COUNTY: McFarlin, 1550: In a ravine along State road 18, near Bristol; and 1445: Rock Bluff; also 1682; 1663: In Johnson's juniper swamp, about 8 miles south of Bristol.

MANATEE COUNTY: A. J. Grout: Reports this species as common throughout the county. H. L. Blomquist: On the edge of a small stream about 6 miles northeast of Manatee. McFarlin, 415: In a low hammock near Manatee.

OKALOOSA COUNTY: McFarlin, 1470. In a low hammock near Galiver.

PINELLAS COUNTY: L. Miller and J. K. Reeves: In swampy soil near St. Petersburg. Specimen deposited in the Duke University herbarium.

POLK COUNTY: O. E., G. K., & B. E. Jennings, 12030: On firm sand humus bottom of rapidly flowing stream near Lake Buffum. Specimen in the Duke University herbarium. McFarlin, 73: Homeland; 52: In Reedy Creep swamp near Loughman; 86, 104, and 110: In a low hammock in Highlands Gully south of Lakeland, 149: In a low hammock about Lake Marion; 204; Winter Haven; 47: Tiger Lake swamp; 383: Deen's; 364: Loughman.

SEMINOLE COUNTY: S. Rapp, 10: On sandy banks and rotten stumps near Sanford.

WALTON COUNTY: D. S. & H. B. Correll, 8465: Growing on the base of cypress trees. Mossy Head. Specimen in the Duke University herbarium.

RICCARDIA S. F. Gray, Nat. Arr. Brit. Pl. **1**: 683, 1821.

Romeria Raddi, Mem. Soc. Ital. Sci. Modena **18**: 48, 1820; not of Medic. 1772.
Aneura Dum. Comm. Bot. 115, 1822.
Trichostylium Corda, Opiz, Beitr. **1**: 1829.
Acrostolia Dum. Rec. d'Obs. 1835.
Sarcomitrium Corda, Sturm Deutschl. Fl. **2**: 120, 1836.
Pseudomeura Gottsche, Mex. Leberm. 259, 1863.
Spinella Schiffn., Exped. Gazelle 42, 1889.

Riccardia latifrons Lindb., Not. pro Fauna et Fl. **13**: 372, 1874.

ALACHUA COUNTY: Little: In the Devil's Millhopper about six miles northwest of Gainesville.
GADSDEN COUNTY: Kurz. In a ravine at Chattachoochee.
HIGHLANDS COUNTY: McFarlin, 1365 and 1371: In a low hammock about Lake Istokpoga.
POLK COUNTY: McFarlin, 540: On a rotten log in Highlands Gully south of Lakeland; 575: In Bettes hammock near Auburndale.
WAKULLA COUNTY: McFarlin, 1422: On an old rotten log in a low hammock near Sopchoppy.
WALTON COUNTY: McFarlin, 1529: In a low hammock near Mossy Head.

Riccardia multifida (L.) S. F. Gray, Nat. Arr. Brit. Pl. **1**: 683, 1821.

ALACHUA COUNTY: Recorded by William A. Murrill in his paper "Bryophytes of Alachua County".
HOLMES COUNTY: McFarlin, 1473: In a low hammock along Holmes Creek near Bonifay.
LIBERTY COUNTY: McFarlin, 1440, 1669, 1672, and 1689: In Johnson's juniper swamp about 8 miles south of Bristol.
SEMINOLE COUNTY: S. Rapp: On logs in wet places, Sanford.

Riccardia palmata (Hedw.) Carruth., in Seem. Jour. Bot. **3**: 302, 1865.

ALACHUA COUNTY: Little: Along creek south of the Athletic Field, Gainesville.
LEON COUNTY: Kurz: About 3 miles from Tallahassee.
POLK COUNTY: McFarlin, 53: Along mucky banks of Reedy Creek near Loughman; 153: On base of live oak in a low hammock on Lake Marion.
SEMINOLE COUNTY: S. Rapp, 27: On a cypress log in a swamp at Sanford.

Riccardia pinguis (L.) S. F. Gray, Nat. Arr. Brit. Pl. **1**: 683, 1821.

ALACHUA COUNTY: Little: Along run on the north side of Gainesville.
COLLIER COUNTY: McFarlin, 1000: In hammocks about Lake Trafford; 1702: In a hammock near Naples.
DADE COUNTY: McFarlin, 1937: On old logs in the Timmes Hammock near Silver Palm.
HOLMES COUNTY: McFarlin, 1471: In a low hammock along Holmes Creek near Bonifay.
HIGHLANDS COUNTY: McFarlin. 1107; and 1433: In Highlands Hammock State Park near Sebring.
JEFFERSON COUNTY: Kurz: About 4 miles southwest of Flint Rock; also about 4 miles from Tallahassee on the Old Spanish Trail.
POLK COUNTY: McFarlin, 15: On a rotten log at Kissengen Spring south of Bartow.
SEMINOLE COUNTY: S. Rapp, 28: On rotten log in swamp, Sanford.

Riccardia sinuata (Dicks.) Trev., Schema Nuov. Class. Epat. 431, 1877.

ALACHUA COUNTY: H. L. Blomquist, 8849: On wet decaying wood in the Devil's Millhopper west of Gainesville. Specimen in the herbarium of Duke University.

PELLIACEAE

FOSSOMBRONIA Raddi, Mem. Soc. Ital. Sci. Modena **18**: 29, 1818.

Codonia Dum., Comm. Bot. 111, 1922.
Jungermannia L., Sp. Pl. Ed. 1, 1136. 1753.

Fossombronia angulosa (Dicks.) Raddi, Mem. Soc. Ital. Sci. Modena **18**: 29, 1818.

LAKE COUNTY: Underwood & Cook, 118: In the vicinity of Eustis in 1891.

Fossombronia braziliensis Steph., Mem. Herb. Boissier **16**: 28, 1900; also Sp. Hep. **1**: 382, 1900.

ALACHUA COUNTY: Reported in "Bryophytes of Alachua County" by William A. Murrill.
CALHOUN COUNTY: McFarlin, 1420: On soil near Altha.
JEFFERSON COUNTY: Kurz: About 4 miles southwest of Flint Rock.
SEMINOLE COUNTY: S. Rapp, 80; On sandy banks, Sanford.

Fossombronia foveolata Lindb., Soc. Fauna et Fl. Fennica, Dec. 6, 1873.

HOLMES COUNTY: McFarlin, 1658: Collected in a low hammock along Holmes Creek near Bonifay, November 8, 1937.

Fossombronia lamellata Steph. Hedwigia **33**: 9, 1894.

SEMINOLE COUNTY: S. Rapp, 80: Collected on moist sandy bank near Sanford, specimen in the Duke University herbarium.

Fossombronia Wondraczekii (Corda) Dum., Rec. d'Obs. 11, 1835.

POLK COUNTY: McFarlin, 215 and 218: In the Gadsen Hammock near Bartow. 371: In the flat woods along the Lakeland-Winter Haven road 3 miles west of Winter Haven.

Fossombronia sp.

Note: The material collected at the following localities was sterile and could not be determined specifically.
HOLMES COUNTY: McFarlin, 1472: In a low hammock near Bonifay.
POLK COUNTY: McFarlin, 343: Along roadside near Kathleen. McFarlin, 369: In the Gadsen Hammock near Bartow.

PELLIA Raddi, Mem. Soc. Ital. Sci. Modena **18**: 38, 1818.

Jungermannia L., Sp. Pl., Ed. 1, 1135. 1753, in part.
Papa S. F. Gray, Nat. Arr. Brit. Pl. **1**: 686. 1821.
Scopulina Dum., Comm. Bot. 115, 1822.
Blasia Fries, Stirp. Fremson. 31, 1825.
Gymnomitrion Hueben., Hep. Germ. 42. 1834.

Pellia epiphylla (L.) Corda, Opiz. Beitr. 654, 1829.

HOLMES COUNTY: McFarlin, 1659: In a low hammock along Holmes Creek near Bonifay.
LIBERTY COUNTY: McFarlin, 1474: In Torreya State Park.
Note: The above collections were sterile and could not be determined specifically with certainty.

LEPIDOZIACEAE

BAZZANIA S. F. Gray, Nat. Arr. Brit. Pl. **1**: 704, 1821.

Bazzanius S. F. Gray, Nat. Arr. Brit. Pl. **1**: 704, 1821.
Herpetium Nees, Eur. Leb. **1**: 96, 1833.
Pleuroschisma Dum., Rec. d'obs. Jung. 19, 1835.
Mastigobyrum G.L.N., Syn. Hep. 214, 1845.

Bazziania trilobata (L.) S. F. Gray, Nat. Arr. Brit. Pl. **1**: 704, 1821.

LIBERTY COUNTY: Kurz: In Johnson's juniper swamp about 8 miles south of Bristol. This is the southern limit for the species.

MICROLEPIDOZIA Joerg., Bergens Museums Skrifter **16**: 303, 1934.

Lepidozia subgen. *Micro-Lepidozia* Spruce, Trans. Bot. Soc. Edinb. **15**: 359, 1885.
Lepidozia subgen. *Microlepidozia* Schiffn., Engler & Prantl. Nat. Pflanz. **1**. (3): 103, 1895.

Microlepidozia setacea (Web.) Joerg., Bergens Museums Skrifter **16**: 303, 1934.

POLK COUNTY: McFarlin, 39: Lakeland.

Microlepidozia sylvatica (Evans) Joerg., Bergens Museum Skrifter **16**: 304, 1934.

ALACHUA COUNTY: Little: About 5 miles south of Gainesville.
CLAY COUNTY: Little: In the vicinity of Kingsley Lake.
JEFFERSON COUNTY: Kurz: About 4 miles southwest of Flint Rock, also about one and a half miles from Drifton.
SEMINOLE COUNTY: L. M. Underwood: Collected at Enterprise. S. Rapp, 25: On sandy banks, Sanford.
VOLUSIA COUNTY: Grout: Near Orange City.

TELARANEA Spruce, Trans. and Proc. Bot. Soc. (Edinb.) **15**: 365, 1885. (As a synonym.) Schiffn., Engl. & Prantl. Nat. Pflanz. **1**(3): 103, 1895.

Telaranea nematodes (Gottsche) M. A. Howe. Notes on American Hepaticae, Bull. Torrey Bot Club, **29**: 1902.

ALACHUA COUNTY: Little: In a bog 5 miles south of Gainesville.
CLAY COUNTY: Little: At Kingsley Lake.
COLLIER COUNTY: McFarlin, 990a: In the Big Cypress swamp west of Deep Lake.
GADSDEN COUNTY: Schornherst, 8x: Jenkin's Spring.
LEON COUNTY: Kurz: About 4 miles from Tallahassee, along the Old Spanish Trail.
LICERTY COUNTY: McFarlin, 1934, 1492, 1664, 1682, 1687, and 1961: In Johnson's juniper swamp about 8 miles south of Bristol.
POLK COUNTY: McFarlin, 47: Tiger Lake swamp; 175: Scot Lake; 258: About 10 miles east of Hesperides.
WALTON COUNTY: McFarlin, 1526, and 1527: Mossy Head.

Telaranea nematodes (Gottsche) var. **longifolia** Howe Bull. Torrey Bot. Club **29**: 284, 1902.

MANATEE COUNTY: Grout: On mucky soil with *Leucobryum,* Flying Eagle Scout Camp about 15 miles east of Manatee.
SEMINOLE COUNTY: S. Rapp, 22: On sandy banks, Sanford.

Note: The following collections were made in Florida without definite records as to counties:—John Donnell Smith, 1877; C. F. Austin, March, 1878; and F. C. Straub, March, 1895.

CALYPOGEIACEAE

CALYPOGEIA Raddi, Mem. Soc. Ital. Mod. **18**: 421, 1820.

Kantius S. F. Gray, Nat. Arr. Brit. Pl. **1**: 706, 1821.
Cincinnulus Dum., Comm. Bot. 113, 1822.

Calypogeia fissa (L.) Raddi, Mem. Soc. Ital. Mod. **18**: 44, pl. 5, fig. 3, 1820.

ALACHUA COUNTY: Recorded as frequent in William A. Murrill's paper "Bryophytes of Alachua County." N. L. T. Nelson: Gainesville.
CLAY COUNTY: Little: Green Cove Springs.
LEON COUNTY: Kurz: About 3 miles west of Tallahassee along the Old Spanish Trail.
LIBERTY COUNTY: McFarlin, 1482: In Torreya State Park.
SEMINOLE COUNTY: S. Rapp, 93: Collected in the vicinity of Sanford, March 1924.

Calypogeia Sullivanti Aust. Hep. Bor. Amer. 74b, 1873.

ALACHUA COUNTY: Little: At the outskirts of Gainesville along the Newberry road.
LEON COUNTY: Kurz: Along wood in a rocky brook on the Meridian road six miles north of Tallahassee.
SEMINOLE COUNTY: S. Rapp, 53: On ditch banks, Sanford.

Calypogeia Trichomanes (L.) Corda Opiz. Beitr. 653, 1829.

ALACHUA COUNTY: Recorded as rare in William A. Murrill's paper, "Bryophytes of Alachua County".
LEON COUNTY: Kurz: Along Harvey's Creek, about 18 miles southwest of Tallahassee.
LIBERTY COUNTY: McFarlin, 1488: In Torreya State Park.
MARION COUNTY: D. S. & H. B. Correll, 8871: On wet swampy soil about 1.5 miles east of Blichton.
SEMINOLE COUNTY: S. Rapp, 54: On sandy banks, Sanford.

CEPHALOZIACEAE

CEPHALOZIA Dum., Rec. d'obs. Jung. 18, 1835.

Jungermannia sect. *Cephalozia* Dum., Syll. Jung. 60, 1831.
Trigonanthus Spruce, Trans. Bot. Soc. Edinb. **3**: 207, 1850.
Cephalozia subgen. *Eucephalozia* Spruce, On Cephalozia 30, 1882.

Cephalozia bicuspidata (L.) Dum., Rec. d'obs. Jung. 18, 1935.

GADSDEN COUNTY: Little: Along the Chattahoochee Ravine at Chattahoochee. Grout: On wet log by creek 5½ miles south of River Junction.
LIBERTY COUNTY: McFarlin, 1550: In a ravine along state road 13, near Bristol.
SEMINOLE COUNTY: S. Rapp: In the vicinity of Sanford.

Cephalozia catenulata (Hüb.) Spruce, On Cephalozia 33, 1882.

CLAY COUNTY: Little: Kingsley Lake.
LIBERTY COUNTY: Kurz: In Johnson's juniper swamp about 8 miles south of Bristol.
SEMINOLE COUNTY: S. Rapp, 35: On rotten logs in a hammock near Sanford.
WAUKULA COUNTY: McFarlin. 1421: On old rotten wood in hammocks near Sopchoppy.
WALTON COUNTY: McFarlin, 1525 to 1527 inclusive: Mossy Head.

Cephalozia connivens (Dicks.) Lindb. Proc. Linn. Soc. **13**: 190, 1872.

ALACHUA COUNTY: Little: In a bog 5 miles south of Gainesville.
HIGHLANDS COUNTY: McFarlin, 606: Sebring.

LAKE COUNTY: L. M. Underwood: Collected in January 1891 near Lisbon and distributed from the U. S. National Herbarium as number 1217.
LIBERTY COUNTY: McFarlin, 1550: In a ravine along state road 18, near Bristol.
POLK COUNTY: McFarlin, 360 and 361: In Reedy Creek swamp near Loughman: 39; 40; and 45: collected near Lakeland; 175 and 176; collected in a high hammock near Scott Lake; 300 and 301: collected in the vicinity of Winter Haven.
SEMINOLE COUNTY: S. Rapp, 32: On swampy ground in vicinity of Sanford.
VOLUSIA COUNTY: F. C. Straub, 207: Collected near Port Orange in February 23, 1895. Specimen in the Underwood herbarium.
WAKULLA COUNTY: McFarlin, 1422: On old rotten wood in a low hammock near Sopchoppy.

Cephalozia macrostachya Kaal., Rev. Bryol. **29**: 8, 1902.; Steph., Spec. Hep. 3: 297, 1908; Nicholson, Hast. and East Sussex Nat. **1**(6): 274, 1911.

JEFFERSON COUNTY: Schornherst, 19x: Along creek beyond Capitola; 33x: Along the Jackson Bluff road. Specimens are in the herbarium of the Florida State College for Women.

Cephalozia media Lindb., Medd. Soc. F. et Fl. Fenn. **6**: 242, 1881.

CLAY COUNTY: Little: Kingsley Lake and Green Cove Springs.
HIGHLANDS COUNTY: McFarlin, 1146: In Highlands Hammock State Park near Sebring.
HOLMES COUNTY: McFarlin, 1662: In a low hammock along Holmes Creek near Bonifay.
SEMINOLE COUNTY: S. Rapp, 34: On sandy banks, Sanford.

ODONTOSCHISMA Dum., Rec. d'obs. Jung. 19, 1835.

Pleuroschisma sect. *Odontoschisma* Dumortier, Syll. Jungerm. Europ. 68, 1831.
Sphagnocetis G. L. N., Syn. Hep. 148, 1844.
Cephalozia subgen. *Odontoschisma* Spruce, On Cephalozia 59, 1882.

Odontoschisma denudatum (Mart.) Dum., Rec. d'obs. 19, 1835.

CLAY COUNTY: Little: Kingsley Lake.
GADSDEN COUNTY: Kurz: Pronto Springs.
JEFFERSON COUNTY: Lighthipe: Monticello.
WAKULLA COUNTY: McFarlin, 1422: On old rotten wood in a low hammock near Sopchoppy.

Odontoschisma prostratum (Swartz) Trevis Mem. Istit. Lomb. 4: 419, 1877.

ALACHUA COUNTY: Little: In a bog about 5 miles south of Gainesville.
CLAY COUNTY: Little: In vicinity of Kingsley Lake.
COLUMBIA COUNTY: Straub: In the vicinity of Lake City.
DUVAL COUNTY: D. S. & H. B. Correll, 8804; On rotten wood and mud in a cypress swamp about 1 mile north of Duval.
HIGHLANDS COUNTY: McFarlin, 1132; 1135; 1138; 1146; 1147; and 1174; Common in Highlands Hammock State Park near Sebring.
LAKE COUNTY: L. M. Underwood: Grand Island; Lisbon; and Eustis.
LIBERTY COUNTY: Kurz: Collected in Johnson's juniper swamp about 8 miles south of Bristol. McFarlin, 1550: In a ravine along state road 18 in the vicinity of Bristol; 1434, 1435, 1436, 1442, 1492, 1493, 1495, 1497, 1498, 1499, 1501, 1664, 1673, 1674, 1676, 1678, 1682, 1685, and 1687: Common in Johnson's juniper swamp, 8 miles south of Bristol.
MANATEE COUNTY: Grout: On soil at Flying Eagle Scout Camp.
NASSAU COUNTY: Eaton: Collected on Amelia Island.
PASCO COUNTY: Underwood: Collected in the vicinity of Blanton.

POLK COUNTY: McFarlin, 39 and 45: Lakeland; 120 and 126: collected in Highlands Gully south of Lakeland; 362 and 365: in a low hammock near Loughman; 175: In a hammock about Scott Lake; 21: On the ground in Bartow swamp; 548: In a low hammock about Lake Rosalie; 257: In a hammock east of Hesperides.

SEMINOLE COUNTY: S. Rapp, 36: Growing over roots and on sandy banks in the vicinity of Sanford.

VOLUSIA COUNTY: Straub: Collected in the vicinity of Port Orange. Grout: On soil, Orange City.

WALTON COUNTY: McFarlin, 1525 and 1526: In a ravine in the vicinity of Mossy Head.

CEPHALOZIELLACEAE

CEPHALOZIELLA (Spruce) Schiffn. Engler & Prantl. Nat. Pflanz. **1**(3): 98, 1895. K. Mull., omend., Rabh. Krypt. Fl. **2**: 786, 1916.

Cephalozia subgen. *Cephaloziella* Spruce, On Cephalozia 62, 1882.

Cephaloziella floridae Douin, Bull. Bot. Soc. France **28**: 312, 1916.

DADE COUNTY: McFarlin, 1343: In hammocks on Key Largo.

HIGHLANDS COUNTY: McFarlin, 1119: In Highlands Hammock State Park near Sebring.

Cephaloziella hylina Douin. Soc. Bot. France, Mem. **29**: 77, 1920.

SEMINOLE COUNTY: S. Happ, 78: On a ditch bank, Sanford, specimen in the herbarium of Duke University.

Cephaloziella obliqua Douin Revue Gen. Bot. **28**: 319. 346, 1916.

SEMINOLE COUNTY: S. Rapp: Sanford.

Cephaloziella obliqua Douin var. **dentata** Douin, Soc. Bot. de France. Mem. **29**: 59, 1920.

SEMINOLE COUNTY: S. Rapp: Collected near Sanford in March, 1924.

Cephaloziella Rappii Douin, Soc. Bot. France, Mem. **29**: 77, 1920.

SEMINOLE COUNTY: S. Rapp, 60: Collected on a ditch bank, Sanford, April 1921; specimen in the herbarium of Duke University. Another collection was made by Rapp, without number, in March, 1924.

Cephaloziella Rappii Douin var. **laevis** Douin.

SEMINOLE COUNTY: S. Rapp: Collected without number at Sanford, March, 1924.

HARPANTHACEAE

LOPHOCOLEA Dum., Rec. d'obs. Jung. 17, 1835.

Jungermannia sect. *Lophocolea* Dum., Syll. Jung. 59, 1831.

Lophocolea heterophylla (Schrad.) Dum., Rec. d'obs. Jung. 17, 1835.

ALACHUA COUNTY: Little: Along a run at the northern edge of Gainesville.

CLAY COUNTY: Little: Kingsley Lake.

LEON COUNTY: Kurz: "Echo Nook," Lake Bradford.

SEMINOLE COUNTY: S. Rapp, 13: On bark and sandy banks, Sanford.

Lophocolea Martiana Nees, in G. L. & N. Syn. Hep. 152, 1845.

ALACHUA COUNTY: Little: In a run along the northern edge of Gainesville.

CLAY COUNTY: Little: Green Cove Springs.

DADE COUNTY: Small & Nash, 480: In the Everglades west of Miami. Small & Carter, 1355; 1371; and 1396: In hammocks near Homestead trail between Cutler and Camp Longview.
GADSDEN COUNTY: Kurz: Aspalaga.
LIBERTY COUNTY: McFarlin, 1476; 1477; and 1488: Torreya State Park.
PASCO COUNTY: L. M. Underwood, 288: Blanton.
SEMINOLE COUNTY: S. Rapp, 1: On rotten logs in hammock near Sanford.

CLASMATOCOLEA Spruce, Hep. of Amaz. et Andes 440, 1885.

Clasmatocolea Doellingeri (Nees) Steph., Spec. Hep. **3**: 28, 1889.

POLK COUNTY: McFarlin, 366: On the trunk of a cabbage palm in Reedy Creek swamp near Loughman.
SEMINOLE COUNTY: S. Rapp, 33: On palmetto roots and logs, Sanford; specimen in the Duke University herbarium.

JUNGERMANNIACEAE

LOPHOZIA Dum. Rec. d'obs. Jung. fasc. 1. 17, 1835

Jungermannia, L., Sp. Pl. 1131, 1753, pro parte.
Jungermannia sect. *Lophozia* Dum., Syll. Jung. 53, 1831.
Jungermannia Dum. Hep. Eur. 68, 1874.
Lophozia subgen. *Dilophozia K.* Müll., Rabh. Krypt. Fl. **6** (1): 659, 1911 pro max. parte.
Lophozia Arnell, Die schwed. Jung. Arten 77, 1925, pro max. parte.

Lophozia Mildeana (Gottsche) Schiffn., Kritisch. Bemerk. Eur. Leb. **3**: 54, 1903.

SEMINOLE COUNTY: S. Rapp, 94: On moist clayey banks about fifteen miles southwest of Sanford.

PLECTOCOLEA Mitt., in Seemann, Fl. Vitiensis 405, 1871

Jungermannia L., Sp. Pl. 1753, pro parte.
Nardia S. F. Gray, Nat. Arr. Brit. Pl. **1**: 694, 1821, pro parte.
Alicularia Corda, Opiz, Beitr. 652, 1829, pro parte.
Solenostoma Mitt., Jour Linn. Soc. Bot. **8**: 51, 1865, pro parte.
Nardia sect. 1 *Eucalyx* Lindb., Bot. Notis. 167, 1872.
Aplozia Dum., Hep. Eur. 55, 1874.
Southbya Husnot, Hep. Gall. 15, 1875.
Eucalyx Breidl., Mitt. Nat. Ver. Steierm. **30**: 291, 1894.
Mesophylla Dum., sensu Corbiere Rev. bryol. **31**: 13, 1904.
Haplozia K. Muell., Rabh. Krypt. Fl. **1** (3): 535, 1909.

Plectocolea crenulata (Sm.) Evans Ann. Bryol. **10**: 42, 1937.

WAKULLA COUNTY: Kurz: Collected between Crawfordville and Arran on Lost Creek. Apparently the first record for the species in Florida and the southern limit of its range.

PLAGIOCHILACEAE

PLAGIOCHILA Dum., Rec. d'obs. Jung. 14, 1835.

Jungermannia Mich., Nov. Pl. Gen. 7, 1729.
Martinellia sect. S. F. Gray, Nat. Arr. Brit, Pl. **1**: 692, 1821.
Radula sect. *Plagiochila* Dum., Syll. Jung. 42, 1831.

Plagiochila floridana Evans Bot. Gaz. **21**: 190, *pl. 15*, figs. 11-17, 1896.

ALACHUA COUNTY: Nelson: Gainesville. H. L. Blomquist, 8855: On base of trees and on rocks in the Devil's Millhopper west of Gainesville, specimen in the Duke University herbarium.

COLLIER COUNTY: McFarlin, 1563: In a pop-ash swamp, (Billy-Kissimmee swamp) about 20 miles east of Immokalee; 493: Deep Lake.

DADE COUNTY: McFarlin, 528: In the Royal Palm State Park. D. S. Correll, 6025 A: On the walls of lime sinks in the Hattie Bauer Hammock near Naranja, specimen in herbarium of Duke University. McFarlin, 1577, 1578, 1582, 1744, and 1749: On the ground and about limestone sinks in the Costello Hammock near Silver Palm; 1905; 1916; and 1917: In the Hattie Bauer Hammock near Modella.

JACKSON COUNTY: Little: Along the Chipola River at Marianna. McFarlin, 1395; 1400; and 1415: in limestone caverns near Marianna.

JEFFERSON COUNTY: Kurz: Nuttall Rise.

LIBERTY COUNTY: McFarlin, 1425; and 1426: Rock Bluff; 1542: In a ravine along State Road 18, near Bristol.

SEMINOLE COUNTY: S. Rapp, 30: On exposed roots, Sanford, specimen in the herbarium of Duke University.

WAKULLA COUNTY: Grout: Wakulla Springs.

Plagiochila ludoviciana Sull., Musc. Allegh. No. 223, 1845.

ALACHUA COUNTY: L. E. Anderson, 5271: On limestone in the Devil's Millhopper northwest of Gainesville, specimen in the herbarium of Duke University. Little: In the Devil's Millhopper. Kurz: About one mile east of Hickory Sink which is approximately 13 miles south of Gainesville.

COLLIER COUNTY: McFarlin, 990; 994; 1056 a; and 1070: In the Big Cypress; 1065: In the Royal Palm Hammock.

DADE COUNTY: McFarlin. 510; and 527: In Royal Palm State Park; 1569, and 1583: In Costello Hammock near Silver Palm. Grout and McFarlin, 1912: In the Hattie Bauer Hammock near Modella.

ESCAMBIA COUNTY: McFarlin, 1454, and 1455: In a low hammock along the Escambia River.

HOLMES COUNTY: McFarlin, 1510, and 1516: In a low hammock along Holmes Creek near Bonifay.

LIBERTY COUNTY: McFarlin, 1444, and 1446: Rock Bluff; 1483, and 1484: In Torreya State Park.

MADISON COUNTY: McFarlin, 1034a: In the vicinity of Madison.

POLK COUNTY: McFarlin, 33: On the trunk of Maples in a hammock near Lakeland; 1731: In hammock near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 31: On tree trunks and exposed roots, Sanford, specimen in the Duke University herbarium.

Plagiochila Smallii Evans, Bull. Torrey Bot. Club **32**: 180-182, *pl. 5*, 1905.

DADE COUNTY: Small & Carter, 1376 and 1411: In hammocks near the Homested trail, between Cutler and Camp Longview. Number 1411 has been taken as the type. Small & Carter, 1388: In the Everglades between Coconut Grove and Cutler. E. G. Britton, 87: In Brickell Hammock near Miami. Small & Wilson, 1520: In the Everglades near Camp Longview. McFarlin, 513: In the Warwick Hammock near Coral Gables (on rocky outcrops). Grout & McFarlin, 1906, and 1908a: In the Hattie Bauer Hammock near Modella.

Plagiochila Sullivantii Gottsche.

BAY COUNTY: Baurbor: On the trunk of Magnolia, Lynn Haven.

BAY COUNTY: Baurbor: On the trunk of Magnolia, Lunn Haven.

DADE COUNTY: Grout: On limestone in the Hattie Bauer Hammock near Modella. McFarlin, 1940; 1949; and 1967: In the Timmes Hammock near Silver Palm.

GADSDEN COUNTY: Little: Collected in the vicinity of Aspalaga.

Plagiochila undata Sull., Musc. Alleg. no. 222, 1845: American Jour. Sc. & Arts 73, 1846.

ALACHUA COUNTY: Little: On the Experiment Station grounds of the University of Florida at Gainesville.
CLAY COUNTY: Little: At Kingsley Lake near Gainesville.
CITRUS COUNTY: Grout: Near Floral City.
HIGHLANDS COUNTY: McFarlin, 1194: In Highlands Hammock State Park near Sebring.
POLK COUNTY: McFarlin. 1739: On the bark of trees in hammocks near Fort Meade.
LIBERTY COUNTY: McFarlin, 1531: Alum Bluff.
SEMINOLE COUNTY: S. Rapp, 14: On exposed roots, Sanford.

SCAPANIACEAE

SCAPANIA Dum., Rec. d'obs. Jung. 14, 1835.

Martinellius Sect. a. p.p. S. F. Gray, Nat. Arr. Brit. Pl. **1**: 691, 1821.
Radula Dum. Comm. Bot. 112, 1823.
Radula Sect. *Scapania* Dum. Syll. Jung. 38, 1831.
Plagiochila sect. II *Scapania* Nees und Montagne in Nees, Naturg. europ. Leberm. **3**: 515, 1838.
Martinellia Lindb., Acta Soc. Sci. Fenn. **70**: 518, 1875.

Scapania nemorosa (L.) Durmort., Rec. d'obs. Jung. 14, 1835.

WAKULLA COUNTY: Kurz: Lost Creek, between Crawfordville and Arran.

Scapania undulata (L.) Dum., Rec. d'obs. Jung. 14, 1835.

OKALOOSA COUNTY: McFarlin, 463: Along stream in low hammock near Galliver.
WALTON COUNTY: McFarlin, 1521; and 1525: Along ditch bank near Argyle.

PORELLACEAE

PORELLA (Dillenius) L. Sp. Pl. ed. 2, 1106, 1753.

Porella Dill., Hist. Musc. 459, 1741.
Bellincinia Raddi, Atti Soc. Ital. Mod. **18**: 18, 1820.
Antoiria Raddi, Atti Soc. Ital. Mod. **18**: 19, 1820.
Cavendishia S. F. Gray, Nat. Arr. Brit. Pl. **1**: 689, 1821.
Madotheca Dum., Comm. Bot. 111, 1822.

Porella platyphylla (L.) Lindb., Acta Soc. Fenn. **9**: 339, 1869.

JACKSON COUNTY: McFarlin, 1394; 1407; 1411; 1412; 1414; and 1415: Collected on rocky limestone outcrops about the caverns north of Marianna.

Porella platyphylloidea (Schwein.) Lindb. Hep. Utveckl. 20. 1877. 9, 1821.

JACKSON COUNTY: Kurz: On limestone cliffs along the Chipola River at Marianna.
UNRECORDED COUNTIES: A. W. Chapman: In west Florida without definite locality.

Porella pinnata L. Sp. Pl. 1106, 1753.

ALACHUA COUNTY: Little: About Lake Wauberg 6 miles south of Gainesville.
GADSDEN COUNTY: Kurz: Near Aspalaga.
HARDEE COUNTY: McFarlin, 1391: Along Little Charlie Bowlegs Creek.
JACKSON COUNTY: McFarlin, 1417: Along the Chipola River near Marianna.
LEE COUNTY: McFarlin, 1043: In a cypress swamp near Naples.
LEON COUNTY: Schornherst 17x: On the south side of Lake Lafayette.
MANATEE COUNTY: McFarlin, 414: In the vicinity of Manatee.

POLK COUNTY: McFarlin, 338: In a low hammock near Kathleen.
SEMINOLE COUNTY: S. Rapp, 3: On tree trunks near base and on exposed roots, Sanford, specimen in the herbarium of Duke University.

RADULACEAE

RADULA Dum. p.p. Comm. Bot. p. 112, 1822; Rec. d'obs. Jung. 13, 1835; Naturgesch, europ. Lebern. **1**: 96, 1833.

Martinellius S. F. Gray p.p., Nat. Arr. Brit. Pl. 1: 691, 1821.
Stephania O. Kuntze, Rev. Gen. Pl. 839, 1891; Schiffn. in Engl. & Prantl, Nat. Pflanz. **I**(3): 113, 1895.

Radula andicola Steph. Hedwigia 23: 114, 1884.

COLLIER COUNTY: McFarlin, 1558; and 1560: Frequent on trunks of the pop ash in the Billie-Kissimmee swamp about 20 miles east of Immokalee. McFarlin, 1071: In the Royal Palm Hammock. McFarlin, 1374: In the Big Cypress.
DADE COUNTY: McFarlin, 1902: In the Nixon Hammock near Homested.
HOLMES COUNTY: McFarlin, 1506; 1507; 1508; and 1520: In hammocks along Holmes Creek near Bonifay.
LEE COUNTY: McFarlin, 999: In a hammock near Lake Trafford.
LIBERTY COUNTY: Kurz: In Johnson's juniper swamp about 8 miles south of Bristol. McFarlin, 1448; and 1494: In Johnson's juniper swamp; 1425: On tree trunks about Rock Bluff.

Radula australis Austin. Bot. Gaz. **I**: 32, 1876.

ALACHUA COUNTY: Wade & Robinson: Gainesville. Little: In the Devil's Millhopper about 6 miles northwest of Gainesville.
DADE COUNTY: D. S. Correll, 6102A: In the Costello Hammock near Silver Palm. J. K. Small and associates: 1377; 1403; 1414; 1432; 1530; 1538; 2817; 2824; 3689; 5234; 5238; 5239; 5249; 5265; 5288; 5296; 5300; 5302; 6145; 6147; 6154; 6156; 6157; 6177; 6183; 6212; 6213; 6224; 6225; 6231; 6237; 7010; 7022; 7023; 7028; 7032; anl 7040. Grout: On shrubs, Timmes Hammock.
MONROE COUNTY: Small & associates: 1524; 1526; 1535; 1548; 1554; 3663; and 7819: Collected on Florida Keys.
POLK COUNTY: McFarlin, 16: On tree trunks, Kissengen Springs.
SEMINOLE COUNTY: S. Rapp, 4; 24; and 40: On trees in hammocks near Sanford.
WAKULLA COUNTY: Kurz: At "Swirl" 3 miles south of Crawfordville.
Note: Collected by Underwood near Blandton (no county record).

Radula caloosiensis Austin, Bull. Torrey Bot. Club **6**: 301, 1879.

ALACHUA COUNTY: H. L. Blomquist, 8851: On bark of trees at the Devil's Millhopper northwest of Gainesville.
COLLIER COUNTY: McFarlin, 991: In hammocks in the Big Cypress.
DADE COUNTY: Grout: On twigs, Hattie Bauer Hammock. McFarlin, 1947 and 1949: In the Timmes Hammock near Silver Palm.
ESCAMBIA COUNTY: McFarlin, 1458: On trunks of trees at Gull Point near Pensacola.
HIGHLANDS COUNTY: McFarlin, 694: In Highlands Hammock State Park near Sebrings.
JACKSON COUNTY: McFarlin, 1398; 1399: In Caverns State Park north of Marianna. Kurz & Little: On limestone cliffs along the Chipola River at Marianna.
LEE COUNTY: Austin: Collected at Caloosa in 1878, the type locality.
MANATEE COUNTY: H. L. Blomquist, 8930A: On bark of trees at the Flying Eagle Boy Scout Camp about 15 miles north of Manatee.
SEMINOLE COUNTY: S. Rapp, 72; and 86: In the vicinity of Sanford.
UNRECORDED COUNTIES: Underwood: Collected near Blandton.

Radula complanata (L.) Dumort. Comm. Bot. 112, 1822.

DADE COUNTY: Grout & McFarlin, 1904 and 1911: In the Hattie Bauer Hammock near Modella. McFarlin, 510: In Royal Palm State Park.

Radula flaccida Lindenb. & Gottsche; G. L. N. Syn. Hep. 726, 1847.

DADE COUNTY: J. K. Small & C. A. Mosier: Collected on the fronds of *Trichomanes sphenoides* Kunze, in the Hattie Bauer Hammock in March, 1915.

Radula Langloisii Castle, Bull. Torrey Bot. Club **52**: 435-438, *fig. 9*, 1925.

CITRUS COUNTY: H. L. Blomquist. 8883: On trees and rocks in the Fern Grottoes, near Pineola.

COLLIER COUNTY: McFarlin, 1055; 1056; and 1066: In the Big Cypress; 1052: In the Royal Palm Hammock.

DADE COUNTY: McFarlin, 1571; 1583; 1585; 1586; and 1587: In the Costello Hammock near Silver Palm; 1914, and 1919: In the Hattie Bauer Hammock near Modella; 1929; and 1950:. In the Timmes Hammock near Silver Palm.

MADISON COUNTY: McFarlin, 1034: Collected in the vicinity of Madison.

WAKULLA COUNTY: Kurz: Collected near Wakulla Springs.

Radula Sullivanti Austin. Bull. Torrey Bot. Club 6: 19, 1875.

ALACHUA COUNTY: L. E. Anderson, 5279: On rotten wood in the Devil's Millhopper northwest of Gainesville.

CALHOUN COUNTY: D. S. Correll, 8577: On wet limestone ledge, near Aspalaga, along the Apalachicola River, specimen in the herbarium of Duke University.

DADE COUNTY: McFarlin, 1572; and 1573: In the Costello Hammock near Silver Palm.

GADSDEN COUNTY: Little: In the vicinity of Aspalaga.

LIBERTY COUNTY: Kurz: In Johnson's juniper swamp about 8 miles south of Bristol. McFarlin, 1437; 1438; 1671; and 1677: In Johnson's juniper swamp south of Bristol.

POLK COUNTY: McFarlin, 1740: On the bark of trees in hammocks near Fort Meade.

FRULLANCIACEAE

FRULLANIA Raddi Atti Soc. Ital. Sc. Mod. 1818; Mem. Mat. Soc. Ital. Sc. Mod. 18 p. 20, 1820; Spruce, Hep. Amaz. et And. p. 3, 1884.

Frullania arietina Tayl., in G. L. et N. Syn. Hep. 413, 1845.

COLLIER COUNTY: McFarlin, 439; 581; and 582: Collected on twigs of small trees and bushes in the vicinity of Deep Lake, March 31, 1931. Specimens determined by A. W. Evans.

DADE COUNTY: A. J. Grout & McFarlin: Collected in Timmes Hammock Feb. 1940.

Frullania Asagrayana Mont., Ann. Sc. Nat. 2: 14, 1842.

COLLIER COUNTY: McFarlin, 997: In the Big Cypress west of Deep Lake.

Frullania Brittoniae Evans. Trans, Conn. Acad. **10**: 15-16, 1897.

POLK COUNTY: McFarlin, 157: In a low hammock about Lake Marion, west of Haines City.

SEMINOLE COUNTY: S. Rapp, 77: On *Magnolia glauca,* in the vicinity of Sanford.

Frullania cobrensis Gottsche; C. Wright, Hep. Cubenses (nomen nudum) Stephani, Hedwigia **33**: 142, 1894.

SEMINOLE COUNTY: S. Rapp, 57: Collected in the vicinity of Sanford, April, 1912.

Frullania cucullata Lindenb. & Gottsche. G. L. & N. Syn. Hep. 782, 1847.

COLLIER COUNTY: A. A. Eaton: Collected near Everglades in March, 1905.
LEE COUNTY: C. F. Austin: Collected at Caloosa, March 1878.

Frullania Donellii Aust., Bull. Torr. Bot. Club **6**: 301, 1879.

JEFFERSON COUNTY: Austin ? On trees in the vicinity of Monticello.
LAKE COUNTY: Austin ? On trees in the vicinity of Eustis.
SEMINOLE COUNTY: S. Rapp, 75: On the bark of various trees near Sanford.
Note: Also recorded without definite locality as collected by Capt. J. Donnell Smith in East Florida. March 1877.

Frullania eboracensis Gottsche, in Lehmann, Pugillus **8**: 14, 1844.

DADE COUNTY: McFarlin, 1944; 1848; 1952; 1953; and 1955: In the Timmes Hammock near Silver Palm.
GADSDEN COUNTY: Kurz: At Flat Creek about 4 miles south of River Junction.
HIGHLANDS COUNTY: McFarlin, 1118; 1122; 1123; and 1159: In Highlands Hammock State Park near Sebring.
LIBERTY COUNTY: McFarlin, 1534; and 1536: On the bark of trees at Alum Bluff; 1667: In Johnson's juniper swamp about 8 miles south of Bristol.
MANATEE COUNTY: McFarlin, 1728: On the trunk of mastic on Long Boat Key northwest of Sarasota.

Frullania inflata Gottsche, G. L. et N. Syn. Hep., 424, 1845.

ALACHUA COUNTY: Little: About Newman's Lake, six miles east of Gainesville.
JEFFERSON COUNTY: Kurz: About seven miles south of Lamont toward Walker Springs.
SEMINOLE COUNTY: S. Rapp, 18; 21; and 44: On tree trunks and branches in the vicinity of Sanford. No. 18 represents the type of *Frullania Rappii* Evans.

Frullania Kunzei Lehm. & Lindb. G. L. et N. Syn., 449, 1845.

ALACHUA COUNTY: Little: Devil's Millhopper about six miles northwest of Gainesville.
CLAY COUNTY: About Kingsley's Lake.
COLLIER COUNTY: McFarlin, 988: In hammocks about Lake Trafford.
ESCAMBIA COUNTY: McFarlin, 1456; 1457; and 1461: In woods near Gull Point, Pensacola.
HIGHLANDS COUNTY: McFarlin, 556; 767; 769; 998; 1055; 1077; 1118; 1123; 1125; 1131; 1156; 1157; 1163; 1168; 1172; and 1184: In Highlands Hammock State Park near Sebring.
LEON COUNTY: Kurz: About 3 miles from Tallahassee on the road to Quincy.
LIBERTY COUNTY: McFarlin, 1540; 1546; 1549; and 1551: Collected in a deep ravine along state road 18, near Bristol; 1479; and 1481: Collected on bark of trees in Torreya State Park; 1428 and 1429: Collected in a high hammock near Rock Bluff; 1535; and 1537: Collected near Alum Bluff.
OKALOOSA COUNTY: McFarlin, 1465; 1466;: In a low hammock along stream near Galliver.
POLK COUNTY: McFarlin, 333; and 334: In a low hammock about six miles west of Lakeland; 1730; 1732; and 1733: In a high hammock near Fort Meade.

MANATEE COUNTY: McFarlin, 404; and 440: In hammocks about Manatee. H. L. Blomquist, 8925 A: On the bark of trees at the Flying Eagle Boy Scout Camp, about 15 miles north of Manatee, specimens in the Duke University herbarium.

SEMINOLE COUNTY: S. Rapp, 42: On shrubs, trunks of trees and branches. Sanford.

Frullania obcordata Lehm. & Lindenb. in G. L. & N. Syn. Hep. 447, 1845.

ALACHUA COUNTY: Little: On trees, along the streets of Gainesville.

COLLIER COUNTY: McFarlin, 1059: In the Big Cypress west of Deep Lake.

ESCAMBIA COUNTY: McFarlin, 1459: On trees, near Gull Point, Pensacola.

HOLMES COUNTY: McFarlin, 1660: In a low hammock along Holmes Creek near Bonifay.

LEON COUNTY: Kurz: Along the Quincy road about 3 miles from Tallahassee.

LIBERTY COUNTY: McFarlin, 1535: Alum Bluff; 1543; 1544; 1545; 1547; and 1548: In a ravine along state road 18, near Bristol; 1480; 1481; 1487; and 1490: In Torreya State Park.

MANATEE COUNTY: H. L. Blomquist, 8917: At Flying Eagle Boy Scout Camp, about 15 miles north of Manatee, specimen in the herbarium of Duke University. McFarlin, 1725; and 1727: On bark of trees on Long Boat Key north of Sarasota.

OKALOOSA COUNTY: McFarlin, 1468: In a low hammock near Galliver.

SEMINOLE COUNTY: S. Rapp, 43: On tree trunks and branches, in the vicinity of Sanford.

WALTON COUNTY: McFarlin, 1522: Argyle.

Frullania plana Sull., Mem. Amer. Acad., New Ser., 4: 175, 1849.

COLLIER COUNTY: McFarlin, 991; and 995: In the Big Cypress west of Deep Lake.

Frullania riparia Hampe in Lehmann. Pugillus 7: 14, 1838.

MARTIN COUNTY: McFarlin, 1590; and 1591: In a hammock bordering on the Connor's Highway near Port Myacca.

POLK COUNTY: McFarlin, 1729: On the bark of an oak in a high hammock near Fort Meade.

Frullania riojaneirensis (Raddi) Spruce, Hep. Amaz. et And. 23, 1884.

DADE COUNTY: J. K. Small, 5273: Collected in March 1915 at the Brickell Hammock, Miami. (This is the first record for the United States. See Bryologist **28**: 91, 1915).

Frullania squarrosa (Nees) Dum., Rec. d'obs. Jung. 13. 1835.

ALACHUA COUNTY: Little: Near Lake Wauberg, 6 miles south of Gainesville, and at Newnan's Lake east of Gainesville.

COLLIER COUNTY: McFarlin, 1556; and 1557: In a pop-ash slough in the Billy-Kissimmee swamp about 20 miles east of Immokalee.

DADE COUNTY: McFarlin, 1960;: In the Timmes Hammock near Silver Palm.

HIGHLANDS COUNTY: McFarlin, 556; 587; 600; 694; 766; 1054; 1055; 1057; 1126; 1128; 1130; 1131; 1134; 1156; 1163; 1164; 1171; and 1173: Collected in Highlands Hammock State Park near Sebring; 1350; 1355; 1357; 1364; 1367; and 1368: In a low hammock bordering Lake Istokpoga.

LEON COUNTY: On the campus at Tallahassee.

LIBERTY COUNTY: McFarlin, 1428: Rock Bluff; 1431: In Johnson's juniper swamp about 8 miles south of Bristol; 1549: In a ravine along state road 18 near Bristol.

MANATEE COUNTY: H. L. Blomquist, 8888: On the base of trees, Manatee, specimen in the Duke University herbarium.

MONROE COUNTY: Grout & McFarlin, 1887; 1888; and 1893: In a Buttonwood hammock about 2 miles north of Flamingo, Cape Sable region.

SEMINOLE COUNTY: S. Rapp, 45: On tree trunks, Sanford.

LEJEUNEACEAE

BRACHIOLEJEUNEA (Spruce) Schiffn. Engler & Prantl., Nat Pflanzenfam. 1(3) 128, 1893.

Brachiolejeunea Spruce p. subg. Hep. Amaz. et And. 131, 1884.
Frullanoides p. p. Raddi Mem. Soc. Ital. Modena Fis **19**: 38. 1823.
Jungermanniae sp. L. et L. 1832, N. ab E. 1838.
Lejeuniae sp. Mont. 1839.
Ptychocoleus Trevis p. p. maj. Trevis. 1877.

Brachiolejeunea bahamensis Evans Bull. Tolley Bot. **35**: 383, *pl. 28. f. 1-14,* 1908.

DADE COUNTY: J. K. Small & Geo. Nash, 464: On Old Rhodes Key south of Miami.

Brachiolejeunea corticalis (Lehm. & Lindb.) Schiffn. Hedwigia **33**: 180, 1894. Evans, Mem. Torr. Bot. Club **8**: 131, *pl. 18 f. 1-11,* 1902.

HIGHLANDS COUNTY: McFarlin, 313: In Highlands Hammock State Park, Sebring. Collected Feb. 5, 1931.

PALM BEACH COUNTY: Underwood, 293: On trees. Lake Worth. This was the first record of the species for the United States.

SEMINOLE COUNTY: S. Rapp, 38: On trunk of live oak in the vicinity of Sanford.

PTYCHOCOLEUS Trevis, Mem. r Ist. Lomb. III **4**: 405, 1877.

Ptychocoleus heterophyllus Evans, Am. Jour. Bot. **5**: 144-150, *fig. 5,* March, 1918.

SEMINOLE COUNTY: S. Rapp, 38: Robinson's Spring, eight miles south of Sanford, collected in May 1917 (Type): Collected in the vicinity of Sanford in March 1911 and again in May 1912.

MASTIGOLEJEUNEA (Spruce) Schiffn. Engler & Prantl., Nat. Pflanzenfam. 1(3) 129, 1893.

Jungermanniae sp. Wils., L. et L. 1934.
Ptychanthi sp. N. ab E. 1838.
Phragmicoma p. p. Syn. Hep 1845.
Lejeuniae sp. Tayl. 1846.
Ptychocoleus p. p. min., *Marchesiniae sp.* et *Thysanathi sp.* Trevis 1877.
Trigono-Lejeunea Spruce 1885.
Lejeunea subg. *Mastigo-Lejeunea* Spruce, Hep. Amaz. et And. 102, 1884.

Mastigolejeunea auriculata (Wils. & Hook.) Schiffn. Engler & Prantl, Nat. Pflanzenfam. 1(3): 129, 1893.

ALACHUA COUNTY: Little: In a run along the northern edge of Gainesville.

CLAY COUNTY: About Kingley's Lake.

CITRUS COUNTY: H. L. Blomquist. 8886: On the base of rocks in the Fern Grottoes at Pineola.

COLLIER COUNTY: McFarlin, 1554; 1555; 1561; and 1562: In a pop-ash slough in Billey-Kissimmee swamp about 20 miles east of Immokalee; 996; 1001a; 1375; 1377; 1378; 1379; 1380; and 1381: In the Big Cypress.

DADE COUNTY: McFarlin, 1338; and 1341: In hammocks on Key Largo; 1342; 1347: In hammocks in the Cape Sable region; 1571; 1575; 1576; 1580; and 1584: In the Costello Hammock near Silver Palm. Grout: Timmes Hammock.

HIGHLANDS COUNTY: McFarlin, 1117: In Highlands Hammock State Park near Sebring; 1369: In a low hammock about Lake Istokpoga.

HOLMES COUNTY: McFarlin, 1511; 1517; and 1519: In a low hammock along Holmes Creek, near Bonifay.

JACKSON COUNTY: McFarlin 1402; 1408; and 1409: In Cavern's State Park north of Marianna; 1416: On bark of trees near the "Locks" at Marianna.

LEE COUNTY: McFarlin, 987; 1045; and 1047: In a cypress swamp near Naples.

LEON COUNTY: Kurz: About 3 miles west of Tallahassee, on the Old Spanish Trail.

LEVY COUNTY: D. S. and H. B. Correll, 8891: On a tree in a low swampy woods near Rosewood.

LIBERTY COUNTY: McFarlin, 1496; and 1502: In Johnson's juniper swamp, about 8 miles south of Bristol; 1423; 1424; 1430; 1447; 1665; and 1668: In woods about Rock Bluff; 1483: In Torreya State Park.

MANATEE COUNTY: H. L. Blomquist, 8926: In hammocks about the Flying Eagle Boy Scout Camp, about 15 miles north of Manatee.

MARION COUNTY: Grout: Near Orange Lake.

MONROE COUNTY: Grout & McFarlin, 1903: In a buttonwood hammock about 2 miles north of Flamingo, Cape Sable Region.

OKALOOSA COUNTY: McFarlin, 1462: In a low hammock near Galliver.

POLK COUNTY: McFarlin, 150: In a low hammock on Lake Marion west of Haines City; 166: On Sweet Gum in high hammock on Scott Lake, Lakeland; 233: In the Bartow swamp near Bartow; 352: On the trunk of *Fraxinus,* on the west side of Lake Hancock; 1731; 1736; 1738: In hammocks near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 19: On the trunks of trees in hammocks about Sanford.

LOPHOLEJEUNEA (Spruce) Schiffn. Engler & Prantl. Nat. Pflanzenfam. 1(3) 129, 1893.

Jungermannia Sect. III *Tamariscineae* a°° p. p. Reinw. B. et N. ab E. 1824.

Phragmicomae sp. Mont. 1845. Schiffn. 1889.

Symbiezidium p. p. Trevis 1877.

Lejeunea subg. *Lopho-Lejeunea* Spruce Hep. Amaz. et And. 129, 1884.

Lopholejeunea Muelleriana (Gottsche) Schiffn. Bot. Jahrb. **23**: 599, 1897.

CLAY COUNTY: Little: In the vicinity of Kingsley Lake.

COLLIER COUNTY: McFarlin, 989: In hammocks about Lake Trafford; 1001a; and 1001b: In the Big Cypress.

COLUMBIA COUNTY: Kurz: About five miles east of Fort White.

DADE COUNTY: McFarlin, 1930: In the Timmes Hammock near Silver Palm. 1913: In the Hattie Bauer Hammock near Modella. Grout: In low hammocks about Lake Istokpoga.

HIGHLANDS COUNTY: McFarlin, 1173: In Highlands Hammock State Park, near Sebring; 1351; 1356; 1358; and 1362. In low hammocks about Lake Istokpoga.

LIBERTY COUNTY: McFarlin, 1425: Rock Bluff; 1686; and 1690: In Johnson's juniper swamp about 8 miles south of Bristol.

OKALOOSA COUNTY: McFarlin, 1467: In a low hammock along a small stream near Galliver.

POLK COUNTY: McFarlin, 1729: On the bark of an oak in a high hammock near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 3; 14; and 40: On the bark of trees in the vicinity of Sanford.

Lopholejeunea Sagraeana (Mont.) Schiffn. in Engler & Prantl. Nat. Pflanzenfam. 1(3): 129, 1893.

ALACHUA COUNTY: Reported by William A. Murrill in his paper "Bryophytes of Alachua County" as being frequent.

DADE COUNTY: J. K. Small & Carter, 1370: In hammocks near the Homestead trial between Cutler and Camp Longview. E. G. Britton, 479: In the Snapper Creek Hammock (Miami); 84: Brickell Hammock, (Miami). Marshall A. Howe, 88: Brickell Hammock. Small & Wilson, 1529: Miami. Small & Wilson, 1503; 1521; and 1533: from the Long Key mainland. Small, 2348: In hammocks on Elliott's key. McFarlin, 1964: In the Timmes Hammock near Silver Palm.

CAUDALEJEUNA (Steph.) Schiffn. Engler & Prantl., Nat. Pflanzenfam. 1(3) 129, 1893.

Phragmicomae sp. Schiffn. 1886.
Thysananthi sp. Steph. 1887.
Odontolejeunea Mitt. 1887. nec Spruce.
Cauda-Lejeunea Steph. subg. Hedwigia **29**: 18, 1890.
Callistolejeunea Spruce Christiania Videns.- Selsk, Ferhandl. 1892.

Caudalejeunea Lehmanniana (Gottsche) Evans Bull. Torrey Bot. Club **34**: 554-557, *pl. 33 f. 1-12*, 1908.

DADE COUNTY: J. K. Small & J. J. Carter, 2812: October 1906 in Long Prairie south of Miami. McFarlin, 1746; 1747; and 1748a: Collected on the bark of various trees in the Costello Hammock near Silver Palm on Feb. 4, 1939. McFarlin, 1931; 1962; and 1965: On small twigs and on the rachis of *Nephrolepis* in the Timmes Hammock near Silver Palm. McFarlin, 1923: In the Hattie Bauer Hammock near Modella.

LEUCOLEJEUNEA Evans. Torreya **7**: 225-227, 1907.

Lejeunea p. p. G. L. & N. Syn. Hep. 1845.
Lejeunea subgenus *Archi-Lejeunea* p. p. Spruce Hep. Amaz. et And. 1884.
Archilejeunea p. p. Schiffn. in Engler & Prantl., Nat. Pflanzenfam. I (3) 130, 1893.

Leucolejeunea clypeata (Schwein.) Evans. Torreya **7**: 227, 1909.

ALACHUA COUNTY: Little: Collected at Newnan's Lake, 6 miles east of Gainesville.

CLAY COUNTY: Little: Near Kingley's Lake.

ESCAMBIA COUNTY: McFarlin, 1450; and 1451: In a low hammock along the Escambia River.

HOLMES COUNTY: McFarlin, 1503; 1504; 1509; 1514; 1517; and 1518: In hammocks along Holmes Creek near Bonifay.

JACKSON COUNTY: McFarlin, 1401: In Caverns State Park near Marianna.

JEFFERSON COUNTY: E. Nelson, 1: Monticello. This was the first record for the species in Florida.

LEON COUNTY: Kurz: Along the Ocklochnee River on State road 1.

LIBERTY COUNTY: McFarlin, 1443; 1494; and 1500: In Johnson's juniper swamp, about 8 miles south of Bristol; 1541; 1544; 1545; 1547; and 1548: In a ravine along State Road 18, near Bristol; 1479, 1481; 1485; 1487; and 1489: On trees in Torreya State Park; 1533: On trees near Alum Bluff.

OKALOOSA COUNTY: McFarlin, 1464; 1465; 1466; 1468; and 1469: In hammocks along a little stream near Galliver.

POLK COUNTY: McFarlin. 333; and 334: In a hammock about six miles west of Lakeland.

WALTON COUNTY: McFarlin, 1523: In the vicinity of Argyle.

Leucolejeunea conchifolia Evans. Torreya **7**: 229, Dec. 1907.

ALACHUA COUNTY: Little: Along run on the northern edge of Gainesville.

ESCAMBIA COUNTY: McFarlin, 1457; and 1459: On trees near Gull Point near Pensacola.

LEON COUNTY: Kurz: About Orchard Pond.

HIGHLANDS COUNTY: McFarlin, 767; 1055; and 1131a: In Highlands Hammock State Park, near Sebring.

MANATEE COUNTY: H. L. Blomquist, 8925 B: At Flying Eagle Boy Scout Camp, about 15 miles north of Manatee, specimen in the Duke University herbarium.

SEMINOLE COUNTY: S. Rapp, 39: On living trees near Sanford.

Leucolejeunea unciloba (Lindenb.) Evans, Torreya **7**: 228-229, 1907.

ALACHUA COUNTY: H. L. Blomquist, 8860: On the bark of trees at the Devil's Millhopper northwest of Gainesville, specimens in the herbarium of Duke University. Little: Devil's Millhopper.

COLLIER COUNTY: Grout: On bark, near Deep Lake.

CLAY COUNTY: Little: Green Cove Springs.

DADE COUNTY: McFarlin, 1581: In the Costello Hammock near Silver Palm; 1926; growing on the fronds of *Tectaria heracleifolia* in the Timmes Hammock near Silver Palm. Grout: Timmes Hammock.

HOLMES COUNTY: McFarlin, 1505; 1660; and 1661: In a low hammock along Holmes Creek near Bonifay.

LEON COUNTY: Kurz: About 3 miles from Tallahassee along the Qunicy road.

LIBERTY COUNTY: McFarlin, 1535; and 1536: Near Alum Bluff; 1666; 1684; and 1688: In Johnson's juniper swamp about 8 miles south of Bristol.

SEMINOLE COUNTY: S. Rapp, 41: On trees in the vicinity of Sanford.

Leucolejeunea xanthocarpa (Lehm. & Lindb.) Evans, Torreya **7**: 229, 1907. Bull. Torrey Bot. Club 35: 172-173, *pl. 7, figs. 12-23,* 1908.

SEMINOLE COUNTY: S. Rapp, 49: On the bark of trees in hammocks, Sanford.

VOLUSIA COUNTY: S. Rapp, 66: In hammocks at DeLeon Springs.

CERATOLEJEUNEA (Spruce) Schiffn. Engler & Prantl., Nat. Pflanzenfam. **1**:(3): 125, 1893.

Jungermanniae sp. Lindenb. Nova Acta Acad. Caes. Leop.-Carol 14, suppl. 23, 1829.

Colura Dum. Recueil d'Obs. sur les Jung. 12, 1835.

Lejeunea Nees von Esenbeck Naturg. der europ. Leberm. **3**: 265, 1838.

Symbiezidii sp. Trevis Mem. r. Ist. Lomb. III **4**: 401, 1877.

Ceratolejeunea Spruce p. subg. Hep. Amaz. et And. 198, 1884.

Ceratolejeunea integrifolia Evans Bull. Torrey Bot. Club **38**: 213-215, *pl. 9, fig. 13-19,* 1911.

ALACHUA COUNTY: Little: Along a run at the northern edge of Gainesville.

CLAY COUNTY: Little: In the vicinity of Kingsley Lake.

DADE COUNTY: McFarlin, 1937: On old logs in the Timmes Hammock near Silver Palm.

DUVAL COUNTY: Kennedy: In the vicinity of Bayard.

POLK COUNTY: McFarlin, 54: At the base of a hardwood tree in Reedy Creek swamp.
SEMINOLE COUNTY: S. Rapp, 37: On the trunks of trees and exposed roots, Sanford, April 12, 1903.

TAXLILEJEUNEA (Spruce) Schiffn. Engler & Prantl. Nat. Pflanzenfam. **1**(3): 125, 1893.

Jungermanniae sp. Sw. 1788 et al.
Lejeunea sp. Dum. 1835. et al.
Lejeunea subg. *Taxi-Lejeunea* Spruce, Hep. Amaz. et And. 221, 1884.

Taxilejeunea obtusangula (Spruce) Evans. Bull. Torr. Bot. Club **38**: 215-218, *fig. 1-17*, 1911.

CLAY COUNTY: Little: About Kingsley Lake.
COLLIER COUNTY: McFarlin, 992; 993; 994; 1001a; and 1054: In the big Cypress.
DADE COUNTY: McFarlin, 1964: In the Timmes Hammock near Silver Palm.
HIGHLANDS COUNTY: McFarlin, 1156; 1161; 1168; 1169; 1172; and 1173: In Highlands Hammock State Park, near Sebring.
JACKSON COUNTY: McFarlin, 1415: In Caverns State Park near Marianna.
LEE COUNTY: McFarlin. 1044: In hammocks near Naples.
SEMINOLE COUNTY: S. Rapp, 37: On logs and trunks of trees near their base, Sanford. Also, Rapp. 70: Collected at Robinson Spring about eight miles south of Sanford.
WAKULLA COUNTY: Kurz. Along the St. Mark's River about 2 miles south of Newport.

EUOSMOLEJEUNEA (Spruce) Schiff. Engler & Prantl., Nat. Pflanzenfam. **1**(3): 124, 1893.

Jungermanniae sp. Reinw. Bl. et N. ab E. 1824.
Frullaniae sp. Dum. 1835.
Ptychanthi Sp. N. ab E. 1838.
Lejeunea subg. 29 *Eusomo-Lejeunea* Spruce, Hep. Amaz. et And. 244, 1884.

Euosmolejeunea clausa (Nees & Mont.) Evans Bryologist **11**: 69, 1908.

ALACHUA COUNTY: Little: Along creek south of the Athletic Field at Gainesville.
CITRUS COUNTY: H. L. Blomquist, 8885: On bark of trees in the Fern Grottoes at Pineola, specimen in the Duke University herbarium.
COLLIER COUNTY: McFarlin, 1001: In the Big Cypress swamp; 1557; 1558; and 1559: In a pop-ash slough in Billey-Kissimmee swamp about 20 miles east of Immokalee.
DADE COUNTY: McFarlin, 527: In the Royal Palm State Park. Grout & McFarlin, 1911: In the Hattie Bauer Hammock near Modella.
HOLMES COUNTY: McFarlin, 1507: In hammocks along Holmes Creek near Bonifay.
LEON COUNTY: Schornherst, 23x: At base of tree near Natural Bridge.
LIBERTY COUNTY: McFarlin, 1427; 1429; and 1447: Rock Bluff; 1433; and 1553: In Johnson's juniper swamp about 8 miles south of Bristol; 1538; 1670; 1681; 1688: Alum Bluff; 1491: In Torreya State Park.
MANATEE COUNTY: H. L. Blomquist, 8935: On base of tree at the Flying Eagle Boy Scout Camp about 15 miles north of Manatee.
POLK COUNTY: McFarlin, 51; and 54; On the base of hardwood trees in the Reedy Creek swamp; 153: In a low hammock on Lake Marion east of Haines City; 115: In Highlands Gully south of Lakeland.
SEMINOLE COUNTY: S. Rapp, 20: On trees in the vicinity of Sanford, specimen in the Duke University herbarium.
WAKULLA COUNTY: Kurz, "The Swirl" about 3 miles south of Crawfordville.

Euosmolejeunea duriuscula (Nees) Evans. Mem. Torrey Bot Club 8: 135, *pl. 18 f. 12-23,* 1902.

ALACHUA COUNTY: Little: In the Devil's Millhopper, about 6 miles northwest of Gainesville. N. L. T. Nelson: Collected in 1916 in the vicinity of Gainesville. H. L. Blomquist, 8861: On the base of trees in the Devil's Millhopper, specimen in the Duke University herbarium.

CLAY COUNTY: Little: In the vicinity of Kingsley's Lake.

COLLIER COUNTY: McFarlin, 1556; and 1560: In a pop-ash swamp in the Billey Kissimmee Swamp about 20 miles east of Immokalee.

DADE COUNTY: McFarlin, 1340: In the Hattie Bauer Hammock near Modella. Grout & McFarlin, 1907; 1922; and 1923: Hattie Bauer Hammock.

ESCAMBIA COUNTY: McFarlin, 1452; and 1453: In a low hammock along the Escambia River, 1460: On trunks of trees near Gull Point, Pensacola.

HIGHLANDS COUNTY: McFarlin, 1349; 1350; 1355; 1362; 1363; 1367; and 1368: In a low hammock on Lake Istokpoga; 1055; 1157; 1165; 1166; 1167; 1187; 1188; 1188a; 1191; 1201; 1222; 1223; and 1228: Collected in Highlands Hammock State Park near Sebring.

HOLMES COUNTY: McFarlin, 1510: In a low hammock along Holmes Creek, near Bonifay.

LIBERTY COUNTY: Kurz: Collected in Johnson's juniper swamp, about 8 miles south of Bristol. McFarlin, 1446: on trunk of trees near Rock Bluff; 1532: collected in the vicinity of Alum Bluff; 1539; 1546; and 1552: In a ravine along state road No. 18, in the vicinity of Bristol; 1478; 1483; 1486; and 1487: In Torreya State Park; 1432; 1438; 1439; 1441; 1675; 1679; 1680; and 1683: collected in Johnson's juniper swamp about 8 miles south of Bristol.

MANATEE COUNTY: H. L. Blomquist, 8917: On bark of trees at the Flying Eagle Boy Scout Camp about 15 miles north of Manatee. McFarlin, 404: In the vicinity of Manatee; 454; and 455: In a hammock in the vicinity of Myakka.

PASCO COUNTY: McFarlin, 235: In the Fern Grottoes, in the vicinity of Pineola.

POLK COUNTY: McFarlin, 121: On trunks of trees in Highlands Gully west of Lakeland; 13: On an old rotten stump in Bartow swamp. O. E., G. K. & B. E. Jennings, 12,010: On roots of *Liquidambar* where it is flooded during the summer, in the Peace River Swamp in the vicinity of Fort Meade, specimen in the Duke University herbarium. McFarlin, 1735; and 1739: In hammocks near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 23: On bark of trees in the vicinity of Sanford.

TAYLOR COUNTY: McFarlin, 1419: In a low hammock near Eridu.

WALTON COUNTY: McFarlin, 1528: In the vicinity of Mossy Head.

Euosmolejeunea parvula Evans. Am. Journ. Bot. 5: 141-144, *f. 4.* March 1918.

SEMINOLE COUNTY: S. Rapp, 86: On bark of trees, January 1917, in the vicinity of Sanford. This collection has been designated as the type. Also collected by S. Rapp, 86a, in the vicinity of Robinson's Spring about 8 miles south of Sanford. May. 1917.

CHEILOLEJEUNEA (Spruce) Schiffn., Engler & Prantl., Pflanzenfam. 1(3): 124, 1893.

Jungermanniae sp. Lindenb. in Lehm. Pupill. IV, 1832.
Lejeuniae sp. Mont. 1940.
Cheilolejeunea Spruce subg. Hep. Amaz. et And. 1884.

Cheilolejeunea decidua (Spruce) Evans, Bull. Torrey Bot. Club **32**: 188-189, 1905.

DADE COUNTY: Small & Carter, 1370 and 1408: In hammocks near the Homestead trail, between Camp Longview and Cutler; Marshall A. Howe, 81: In the Brickell Hammock (near Miami); Small & Wilson, 1550: In the Everglades near Camp Longview; Small & Wilson, 1551: On Long Key Mainland; McFarlin, 1574: In the Costello Hammock near Silver Palm, April 23, 1838; and 1935; 1939; 1954: In the Timmes Hammock near Silver Palm.

Cheilolejeunea polyantha Evans, Mem. Torrey Bot. Club **8**: 141-143,*pl. 19. figs. 12-21,* 1902.

LAKE COUNTY: Underwood, 1380 p.p.: On bark, Eustis. (type locality).

POLK COUNTY: O. E., G. K. & B. E. Jennings, 12018: Collected in the Peace River swamp near Fort Meade, Dec. 24, 1916, specimen in the Duke University herbarium.

SEMINOLE COUNTY: S. Rapp, 61: On trees in the vicinity of Sanford.

RECTOLEJEUNEA Stephani, Species Hepaticarum **5**: pp. 678-701, 1914.

Rectolejeunea Berteroana (Gottsche) Evans Bull. Torrey Bot. Club **33**: 12, 1906.

PALM BEACH COUNTY: Underwood: On trees, Lake Worth, Florida.

Rectolejeunea Brittoniae Evans Bull. Torr. Bot. Club **38**: 209-212, *pl. 9, fig. 1-12,* No. 5, Ma. 1911.

ALACHUA COUNTY: Little: On trees along creek south of the Athletic Field, Gainesville. N. L. T. Nelson: collected at Gainesville in 1916.

DADE COUNTY: McFarlin, 523; and 1345: On trees in hammocks on Key Largo; 1747: On bark of trees in the Costello Hammock near Silver Palm.

HIGHLANDS COUNTY: McFarlin, 1328: In Highlands Hammock State Park near Sebring.

POLK COUNTY: O. E., G. K. & B. E. Jennings, 12068: On the bark of *Taxodium* near the base of tree along Charlie Bowlegs Creek south of Fort Meade in 1916, specimen in the Duke University herbarium.

SEMINOLE COUNTY: S. Rapp, 63: On bark anl on exposed roots, in the vicinity of Sanford, specimen in the herbarium of Duke University.

Rectolejeunea Maxonii Evans Bull. Torrey Bot. Club **39**: 609, *pl. 45, fig. 17-27,* 1912.

ALACHUA COUNTY: N. L. T. Nelson: 79; and 92: On bark of tree in the vicinity of Gainesville. H. L. Blomquist, 8852: On bark of trees at the Devil's Millhopper northwest of Gainesville.

SEMINOLE COUNTY: S. Sapp, 87: At Robinson's Spring eight miles south of Sanford.

Rectolejeunea phyllobola (Nees & Mont.) Evans Bull. Torrey Bot. Club **35**: 15, 1906.

Reported as collected on trees in Florida by Underwood without definite locality.

CROSSOTOLEJEUNEA (Spruce) Schiffn. Engler & Prantl., Planzenfam. I (3): 127, 1893.

Lejeuniae sp. Lehm., Mont., N. ab E. Naturg. der erurop. Leberm. **3**: 265, 1838.

Crossotolejeunea Spruce subg. Hep. Amaz. et And. 1884.

Crossotolejeunea bermudiana Evans. Bull Torr. Bot. Club **33**: 132, *pl. 6*, 1906.

ALACHUA COUNTY: Little: In the Devil's Millhopper about 6 miles northwest of Gainesville.

SEMINOLE COUNTY: S. Rapp, 65: On the bark of trees in Upsala Swamp, Sanford. S. Rapp, 67: On cypress in the vicinity of Sanford, specimen in the Duke University herbarium.

WAKULLA COUNTY: Kurz: "The Swirl" about 3 miles south of Crawfordville.

UNRECORDED COUNTY: S. C. Hood, 37 & 43: Collected near New Hawkinsville in May 1912.

DREPANOLEJEUNEA (Spruce) Schiffn., Engler & Prantl., Pflanzenfam. **1**(3): 126, 1893.

Jungermanniae sp. Hook. 1816.
Pandulphinius p.p. S. F. Gray 1821.
Lejeuniae sp. Dum. 1822.
Lejeuniea Sect. 2. *Lejeuniotypus* p.p. Dum. 1831.
Lejeunea b *Lejeuneotypus* a, p.p S. O. Lindb. 1875.
Lejeunea subg. *Drepano-Lejeunea* Spruce, Hep. Amaz. et And., 186, 1884.

Drepanolejeunea bidens (Steph.) Evans Bull. Torr. Bot. Club **30**: 29, 1903.

DADE COUNTY: McFarlin, 1741: On the fronds of *Dryopteris reptans*, in the Costello Hammock near Silver Palm; 1742: On the fronds of *Tectaria heracleifolia*, also 1743: On the fronds of *Campyloneuron Phyllitidis*, both in the Costello Hammock, Feb. 4, 1939.

LEPTOLEJEUNEA (Spruce) Schiffn., Engler & Prantl., Nat. Pflanzenfam. **1**(3): 126, 1893.

Jungermanniae sp. N. ab E. 1830 et al.
Lejeunia sp. (Neesii), Mont. 1836.
Colura p.p min Trevis 1877.

Leptolejeunea elliptica (Lehm. & Lindenb.) Schiffn. Pflanzenfam. **1**(3): 126, 1893.

DADE COUNTY: J. K. Small & R. L. Lowe. 7024; 7036; 7041; and 7042: On the leaves of various plants in the Royal Palm Hammock in Jan. 1916; Small, 7045; 7047; 7058; 7060; and 7062: In the same locality in January 1916; Small, 7063: Long Key Hammock. This was the first record of this species for the United States.

LEJEUNEA Libert, Ann. Gen. Sci. Phys. **6**: 372, 1820.

Lejeunea subgen. *Eu-Lejeunea* Spruce, Hep. Amaz. et And. 260, 1884.
Eulejeunea Schiffn., Eng. Prantl. Nat. Pflanz. **1**(3): 122, 1893.
Eulejeunea subg. *Architypica* Massalongo, Jubul. Fl. Ital. 6, 1912.

Lejeunea cladogyna Evans, Am. Jour. Bot. **5**: 134-137, *fig. 2*, 1918.

ALACHUA COUNTY: Little: In the Devil's Millhopper about 6 miles northwest of Gainesville. N. L. T. Nelson, 104: In the vicinity of Gainesville in 1916.

COLLIER COUNTY: McFarlin, 989: In hammocks about Lake Trafford; 1071: In the Royal Palm Hammock.

DADE COUNTY: McFarlin, 1343: In hammocks on Key Largo; 1745; and 1748: On the bark of various trees in the Costello Hammock near Silver Palm; 1945; 1946; and 1951: In the Timmes Hammock near Silver Palm.

HIGHLANDS COUNTY: McFarlin, 1190; 1200; and 1334: In Highlands Hammack State Park near Sebring; 1348; 1358; and 1370: In low hammocks about Lake Istokpoga.

JACKSON COUNTY: McFarlin, 1397; and 1399: In Caverns State Park north of Marianna.

LEE COUNTY: C. F. Austin: Near Caloosa without date.

LEON COUNTY: Kurz: Near the Ocklochnee River bridge on State Road No. 1.

MARION COUNTY: Grout: Near Bellview; in the vicinity of Rainbow Sprnigs; near Orange Lake on limestone.

MARTIN COUNTY: McFarlin, 1592: In a hammock bordering on the Connor's Highway near Port Myacca.

MANATEE COUNTY: Grout: Near Rye bridge.

POLK COUNTY: McFarlin, 1732; and 1740: On bark of trees and old logs in high hammock near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 6; 19; 64; 64a; and 69: Collected in the vicinity of Sanford. No. 64 has been designated as the type collection.

Lejeunea flava (Swartz) Nees Eur. Leb. **3**: 277, 1838.

ALACHUA COUNTY: N. L. T. Nelson: In the vicinity of Gainesville. H. L. Blomquist; 8848: At the base of trees on the south side of Devil's Millhopper about 6 miles northwest of Gainesville, specimen in the herbarium of Duke University.

CLAY COUNTY: Little: Near Kingsley Lake.

CITRUS COUNTY: Grout: On bark of trees near Floral City.

DADE COUNTY: D. S. Correll; 6102 A: On rotton logs in the Costello Hammock near Silver Palm, specimen in the Duke University herbarium. McFarlin, 1743: On fronds of *Campyloneuron Phyllitides,* in the Costello Hammock. Grout & McFarlin, 1899 and 1900: In a low hammock about 4 to 6 miles south of Paradise Key on the road to Cape Sable; 1968: In the Timmes Hammock near Silver Palm. Grout: In the Hattie Bauer Hammock near Modella.

DUVAL COUNTY: Schornherst, 12 x: Near Fort George ruins, Jacksonville.

HIGHLANDS COUNTY: McFarlin, 313; 1202; and 1333: In Highlands Hammock State Park near Sebring.

LEE COUNTY: McFarlin, 987: In a hammock near Naples.

LEON COUNTY: Kurz: About 3 miles from Tallahassee. Schornherst, 4 x: Near Silver Lake.

LIBERTY COUNTY: McFarlin, 1480; and 1490: In Torreya State Park.

MANATEE COUNTY: McFarlin, 399: In hammocks in the vicinity of Manatee.

MARION COUNTY: Grout: Near Bellview.

PASCO COUNTY: McFarlin, 235: In the vicinity of Pineola.

POLK COUNTY: McFarlin, 33; and 35: On the trunks of red maples in a low hammock near Lakeland; 6; and 13: In low hammocks about Kissengen Springs; 152: At the base of a live oak on Lake Marion; 260: About 10 miles east of Hesperides; 584: On trunks of citrus trees in Winter Haven; 552: In a low hammock about Lake Rosalie; 1734: On the bark of trees in a low hammock near Fort Meade.

SEMINOLE COUNTY: S. Rapp, 18: On trees near the base and on roots in the vicinity of Sanford.

VOLUSIA COUNTY: Grout: On Palmetto about Lake Beresferd.

WAKULLA COUNTY: Schornherst, 1 x; 2 x: Newport.

Lejeunea floridana Evans, Bull. Torrey Bot. Club **32**: 185-188, *pl. 5. f. 15-21,* 1905.

ALACHUA COUNTY: N. L. T. Nelson: In the vicinity of Gainesville.

CLAY COUNTY: Little: In the vicinity of Kingsley Lake.

DADE COUNTY: Small & Carter; 1355 and 1356: In hammocks near the Homestead trail between Cutler and Camp Longview. The type has been designated as No. 1355.

HIGHLANDS COUNTY: McFarlin, 1321: In Highlands Hammock State Park near Sebring.

POLK COUNTY: McFarlin, 101: In Highlands Gully south of Lakeland; 171: In a high hammock about Scott Lake south of Lakeland.
SEMINOLE COUNTY: S. Rapp, 11: On logs in the vicinity of Sanford.

Lejeunea glaucescens Gottsche, G. L. & N. Syn. Hep. 378, 1845.

ALACHUA COUNTY: Little: At the Devil's Millhopper northwest of Gainesville.
COLLIER COUNTY: McFarlin, 1038; 1053; and 1060: In the Big Cypress west of Deep Lake.
DADE COUNTY: E. G. Britton; 32: In the Brickell Hammock.
GADSDEN COUNTY: Kurz: In the vicinity of Pronto Springs.
HIGHLANDS COUNTY: McFarlin, 1318: In Highlands Hammock State Park near Sebring.
SEMINOLE COUNTY: S. Rapp, 55: On logs at Sanford.

Lejeunea longifissa Steph., Sp. Hep. 5: 747, *fig. 3,* 1915, "Noteworthy Lejeuneae from Florida" in Am. Jour. Bot. **5**: 137-140, *fig. 3,* 1918.

CLAY COUNTY: Little: In the vicinity of Kingsley Lake.
SEMINOLE COUNTY: S. Rapp, 83: In the vicinity of Sanford in 1917.

STYLOLEJEUNEA Sim. Roy. Soc. So. Africa, Trans. **15**: 67, 1926.

Stylolejeunea pililoba (Spruce) Evans Bryologist **43**: 3, 1940.

BREVARD COUNTY: Austin: On bark or on the ground along the Indian River, specimen in the Austin herbarium.
LEVY COUNTY: Austin: On bark or on the ground at Cedar Keys, specimen in Austin herbarium.
POLK COUNTY: Jennings: In the vicinity of Fort Meade in 1916.

Stylolejeunea spiniloba (Lindenb. & Gottsche) Evans Bryologist **43**: 4, 1940.

CHARLOTTE COUNTY: M. S. Taylor: Near Alva in 1930.
HILLSBOROUGH COUNTY: S. Rapp: In the vicinity of Tampa in 1916.
JACKSON COUNTY: Kurz: Near Marianna and also, in the vicinity of Blue Spring in 1927. Little: Along the Chipola River at Marianna.
SEMINOLE COUNTY: S. Rapp, 71: Near Sanford in 1913, also, Rapp, on the trunk of a cypress near Sanford in 1917.
WAKULLA COUNTY: Kurz: About 3 miles south of Newport on the St. Marks River in 1927.

MICROLEJEUNEA (Spruce) Jack et Steph., Bot. Central. **60**: 11, 1894.

Lejeunea subg. *Micro-Lejeunea* Spruce, Hep. et And. 286, 1884.
Eulejeunea subgen. *Microlejeunea* Schiffn., in Eng. & Prantl. Nat. Pflanzenfam. **1**(3): 124, 1893.

Microlejeunea bullata (Tayl.) Evans, Mem. Torrey Bot. Club **8**: 164-165, *pl. 21, figs. 20-29,* 1902.

ALACHUA COUNTY: N. L. T. Nelson: In 1916 at Gainesville.
COLUMBIA COUNTY: Kurz: About 5 miles east of Fort White.
DADE COUNTY: McFarlin, 1920: In the Hattie Bauer Hammock near Modella; 1939: In the Timmes Hammock near Silver Palm.
HIGHLANDS COUNTY: McFarlin, 1356: In a low hammock on Lake Istokpoga; 694; 695; 1054; and 1173: In Highlands Hammock State Park near Sebring.
LIBERTY COUNTY: McFarlin, 1486: In Torreya State Park.
MANATEE COUNTY: H. L. Blomquist, 8925: On bark of trees at the Flying Eagle Boy Scout Camp, 15 miles north of Manatee.
SEMINOLE COUNTY: S. Rapp, 19: On roots and trunks of trees in the vicinity of Sanford.

Microlejeunea late-virens (Nees & Mont.) Evans. Bryologist **11**: 67-69, 1908.

ALACHUA COUNTY: N. L. T. Nelson: In 1916 in the vicinity of Gainesville. H. L. Blomquist, 8877: On the bark of trees in the Devil's Millhopper northwest of Gainesville, specimen in the herbarium of Duke University.

COLLIER COUNTY: McFarlin, 1071a: In the Royal Palm Hammock; 1558; and 1559: In a pop-ash slough in the Billey-Kissimmee swamp about 20 miles east of Immokolee.

DADE COUNTY: McFarlin, 1346: In hammocks about the Cape Sable Region; 510: In the Royal Palm State Park. D. S. Correll, 6102 A: on rotten logs in the Costello Hammock near Silver Palm, specimen in the herbarium of Duke University. McFarlin, 1566; 1567; 1568; 1570; 1579; and 1588: In the Costello Hammock near Silver Palm; 1927: 1941; 1950; and 1966: In the Timmes Hammock near Silver Palm. Grout & McFarlin, 1904: In the Hattie Bauer Hammock near Modella.

ESCAMBIA COUNTY: McFarlin, 1458: On the bark of trees near Gull Point, Pensacola.

GADSDEN COUNTY: Kurz: Aspalaga.

HIGHLANDS COUNTY: McFarlin, 1184; and 1201: In Highlands Hammock State Park, near Sebring.

JACKSON COUNTY: McFarlin, 1409; and 1410: In Caverns State Park north of Marianna.

LIBERTY COUNTY. McFarlin, 1538: Alum Bluff.

MANATEE COUNTY: H. L. Blomquist, 8930A: On the bark of trees about the Flying Eagle Boy Scout Camp, 15 miles north of Manatee, specimen in the Duke University herbarium. McFarlin, 458: In a low hammock along the Myakka River; 1726: On the trunk of red cedar on Long Boat Key.

MONROE COUNTY: Grout & McFarlin, 1887; 1889; and 1898: In a buttonwood hammock about 2 miles north of Flamingo, Cape Sable region.

POLK COUNTY: McFarlin, 17; and 20: In a low hammock about Kissengen Springs; 154; and 157: In a low hammock east of Haines City on Lake Marion; 583: In the vicinity of Winter Haven.

SEMINOLE COUNTY: S. Rapp, 15: On the bark of various trees in the vicinity of Sanford.

VOLUSIA COUNTY: Grout: Orange City.

Microlejeunea ulicina (Tayl.) Evans. Mem. Torr. Bot. Club **8**: 176, 1902.

POLK COUNTY: McFarlin, 16: On the bark of *Celtis,* in a low hammock at Kissengen Springs.

SEMINOLE COUNTY: S. Rapp, (without number) Sanford.

DIPLASIOLEJEUNEA (Spruce) Schiffn., Engler. & Prantl., Pflanzenfam. **1**(3): 121, 1893.

Jungermanniae sp. Meifsn. in Spreng. 1827.
Lejeuniae sp. Mont. et N. ab E. 1843.
Diplasiolejeunea Spruce subg. Hep. Amaz. et And. 301, 1884.

Diplasiolejeunea Rudolphiana Steph., Hedwigia **35**: 79, 1896.

DADE COUNTY: Small & Wilson, 2058: Collected in hammocks along the Homestead trail, near Camp Longview. This specimen was first erroneously reported as *Diplasiolejeunea unidentata* (Lehm. & Lindenb.) Schiffn., but belongs to the above species.

SEMINOLE COUNTY: S. Rapp, 68: On rotten logs in a swamp in the vicinity of Sanford.

COLOLEJEUNEA (Spruce) Schiffn., Engler & Prantl., Pflanzenfam. 1(3): 121, 1893.

Jungermanniae sp. Sm. Engl. Bot. 1806, Hook. 1816.
Lejeunia Sect. 2 *Lejeuniotypus* p.p. Dum. 1831.
Lejeunea a *Gompholobus* et b. *Lejeuneotypus* B, p.p S. O. Lindb. 1875.
Lejeuneae et *Symbiezidii sp.* Trevis, 1877.
Lejeunea subg. *Colo-Lejeunea* Spruce, Hep. Omaz. et And. 291, 1884.

Cololejeunea biddlecomiae (Aust.) Evans, Mem. Torrey Bot. Club 8: 168, 1902.

DADE COUNTY: Grout & McFarlin, 1901: In a low hammock about 4 to 6 miles south of Paradise Key on the road to Cape Sable. Specimen growing on the bark of *Ficus aurea.*

Cololejeunea contractiloba Evans, Amer. Jour. Bot. 5: 131, fig. 1. 1918.

SEMINOLE COUNTY: S. Rapp, 76: On bark of trees in the vicinity of Sanford. According to Evans this is the only known locality for this species. *Cololejeunea Biddlecomiae* (Aust.) Evans was erroneously reported from Florida but this collection is referable to the above species. Specimen in the herbarium of Duke University.

Cololejeunea diaphana Evans Bull. Torr. Bot. Club 32: 184, *pl. 5. fig. 9-14,* 1905.

Physocolea diaphana Steph. Sp. Hepat. 5: 913, 1916.

ALACHUA COUNTY: N. L. T. Nelson: Collected in the vicinity of Gainesville in 1916 without number. Also Little, (without number) Along a run on the northern edge of Gainesville.
DADE COUNTY: Small & Carter, 1365; and 1370: In hammocks near the Homestead trail between Cutler and Camp Longview. Number 1365 may be taken as the type.
HIGHLANDS COUNTY: McFarlin, "A": Collected on the bark of an oak in Highlands Hammock State Park near Sebring July 5, 1939.
SEMINOLE COUNTY: S. Rapp: In the vicinity of Sanford.

Cololejeunea minutissima (Sw.) Schiffn. Engler & Prantl. Nat. Pflanzenfam. I: 122, 1893.

ALACHUA COUNTY: Little: About Newnan's Lake, 6 miles east of Gainesville.
HIGHLANDS COUNTY: McFarlin, 1354 and 1366: In a low hammock about Lake Istokpoga.
LEE COUNTY: McFarlin, 1046: In a Cypress swamp near Naples.
LEON COUNTY: Kurz: In the vicinity of Lake Munson.
POLK COUNTY: McFarlin, 5: In the vicinity of Kissengen Springs.
SEMINOLE COUNTY: S. Rapp, 15, and 75: On the trunk of trees in the vicinity of Sanford, specimen in the herbarium of Duke University.

Cololejeunea ornata Evans. Bryologist 41: 73-79, figs. 1-20, 1938.

JACKSON COUNTY: Kurz and Kennedy, 145: "Collected on xerophytic limestone cliffs along the Chipola River, March 27, 1927." Kurz, 269; On limestone along the Dothan Highway about eight mile snorthwest of Marianna, Feb. 5, 1938.

Cololejeunea setiloba Evans. Bryologist 16: 51-54, *fig. 1-7,* 1913.

SEMINOLE COUNTY: S. Rapp, 12: The type was collected on the trunk of *Myrica,* Jan. 28, 1906. S. Rapp. 27; and 59: On the bark of *Ilex glabra.* All collections made in the vicinity of Sanford .

Cololejeunea subcristata Evans. Bryologist **20**: 24, *f. 5-14,* 1917.

DADE COUNTY: Small & Mosier, 5327: Collected on the leaves of *Tectaria minima* Underw. in the Hattie Bauer Hammock; 6008: On the fronds of *Trichomanes Krausii* Hook. & Grev. in the Nixon-Lewis Hammock; McFarlin, 1915: In the Hattie Bauer Hammock near Modella.

Cololejeunea tuberculata Evans. Bryologist **18**: 84, *f. 1-9,* 1915.

ALACHUA COUNTY: Little: Along creek south of the Athletic Field, Gainesville. McFarlin, 1866: In the Devil's Millhopper about 6 miles northwest of Gainesville.

DADE COUNTY: Small, Small, and Mosier: 5250: On the fronds of *Trichomanes Krausii;* Hook. & Grev. during March, 1915 in the Nixon-Lewis Hammock; 5257: In the Sykes Hammock, and about the pinelands near Timmes Hammock; In the Hattie Bauer Hammock on the fronds of *Trichomanes sphenoides,* Kunze.

LEPTOCOLEA (Spruce) Evans, Bull. Torrey Bot. Club **38**: 260-262, 1911.

Lejeunea, subgenus *Colo-lejeunea,* section *Leptocolea,* Spruce, Hep. Amaz. et And. 292, 1884.

Cololejeunea subgenus *Leptocolea* Schiffn., in Engler & Prantl., Nat. Pflanzenfam. **1**(3): 122, 1893.

ALACHUA COUNTY: Little: In the vicinity of a creek south of the Athletic Field at Gainesville.

COLUMBIA COUNTY: Kurz: About 2 miles east of Fort White along the road to Lake City.

LAKE COUNTY: L. M. Underwood; 100: At Lisbon.

SEMINOLE COUNTY: S. Rapp, 5; 92; and 93: Collected in the vicinity of Sanford.

APHANOLEJEUNEA Evans, Bull. Torrey Bot. Club **38**: 272-273, 1911.

Aphanolejeunea sicaefolia (Gottsche) Evans, Bull. Torrey. Bot. Club **38**: 277, *pl. 12, f. 18-26,* 1911.

DADE COUNTY: Small & Moiser, 5287: In the Timmes Hammock, and in the pinelands about Nixon-Lewis Hammock, on the leaves of *Trichomanes Krausii* in March 1915.

SEMINOLE COUNTY: S. Rapp, 69: Vicinity of Sanford, in March 1924.

ANTHOCEROTACEAE

ANTHOCEROS (Micheli) L., Sp. Pl. 1139, 1753.

Anthoceros Mich., Gen. Pl. 10, 1729.

Anthoceros carolinianus Michx., Fl. Bor. Americ.: 280, 1803·

ALACHUA COUNTY: Little: Along creek south of the Athletic Field at Gainesville D. S. & H. B. Correll, 8909; also, H. L. Blomquist, 8862: From the Devil's Millhopper northwest of Gainesvile, specimen in the herbarium of Duke University.

HIGHLANDS COUNTY: McFarlin, 1336: In Highlands Hammock State Park, near Sebring.

MARION COUNTY: D. S. & H. B. Correll, 8868: On muddy soil along a small wooded stream 1½ miles east of Blichton.

LEON COUNTY: Kurz: About 3 miles from Tallahassee, along Route 1, towards Quincy.

LIBERTY COUNTY: McFarlin, 1475: In muddy places in Torreya State Park.

SEMINOLE COUNTY: S. Rapp, 46: On earth and logs in the vicinity of Sanford.

Anthoceros Donnellii Aust., Bull. Torr. Bot. Club **6**: 304, 1875.

MANATEE COUNTY: McFarlin, 400: Near the town of Manatee.

UNRECORDED COUNTIES: Along the Caloosahatchee River in southwest Florida by Coe F. Austin without definite locality and reported by L .M. Underwood in 1884.

Anthoceros laevis L., Sp. Pl. 1139, 1753.

ALACHUA COUNTY: Little: Along creek south of the Athletic Field, Gainesville.

LEON COUNTY: Kurz: On the campus of the Florida State College for Women at Tallahassee.

POLK COUNTY: McFarlin, 216: On soil in Gadsen Hammock near Bartow; 258: About 10 miles east of Hesperides; 319: West of Lakeland; 360: On mucky banks in the flatwoods near Loughman; 1076: In Faulkner Hammock near Bartow.

MANATEE COUNTY: H. L. Blomquist, 8907: On soil at edge of small stream about 6 miles east of Manatee. McFarlin, 422: Manatee.

Anthoceros Olneyi Aust., Bull. Torr. Bot. Club **6**: 29, 1875.

UNRECORDED COUNTIES: Reported by L. M. Underwood in his "Hepatics of North America", as collected in Florida by Chapman without definite locality. Communicated by Stephen T. Olney.

Anthoceros punctatus L., Sp. Pl. 1139, 1753.

ALACHUA COUNTY: Little: Along creek south of Athletic Field, Gainesville.

LEON COUNTY: Kurz: About 3 miles from Tallahassee, along route 1, towards Quincy.

POLK COUNTY: McFarlin, 139: On wet muddy soil about Kissengen Springs, 4 miles south of Bartow; 266: About 2 miles east of Homeland.

SEMINOLE COUNTY: S. Rapp, 47: On sandy banks, earth and logs near Sanford.

Anthoceros punctatus L. var **Eatoni** Aust., Bull. Torr. Bot. Club **6**: 27, 1875.

UNRECORDED COUNTIES: It was collected on the St. John's and Indian Rivers by J. Donnell Smith, and listed by L. M. Underwood in "Hepatics of North America."

Anthoceros Ravenellii Aust., Bull. Torr. Bot. Club **6**: 28, 1875.

POLK COUNTY: McFarlin, 359: Fort Meade; 378: Kissengen Springs; 379: East of Brewster.

SEMINOLE COUNTY: S. Rapp, 82: Collected in Sanford, March 1924.

UNRECORDED COUNTIES: Listed by L. M. Underwood in his paper "Hepatics of North America," as on moist earth, Florida, collected by Austin in 1884.

NOTATHYLAS Sull., Musci Alleg. exs. Nr. 288-290, 1846; **Mem.** Amer. Acad. of Arts and Sci. New Ser., **3**: 65, 1848.

Carpobulus Schwein., Jour. Acad. Phila. **2**: 367, 1821.
Chamaeceros Milde, Nova Acta Acad. Leop-Carol. **26**: 167. 1856.

Notothylas orbicularis (Schwein.) Sull., Musci and Hep. of United States 685, 1856.

POLK COUNTY: McFarlin, 14: On an old log at Kissengen Springs about 4 miles south of Bartow.

FLORIDA'S TAX PROBLEM

George P. Hoffman
Florida Southern College

The paper opens with a brief description of the common sources of public revenue in Florida, with an analysis of the conflict of authority which arises from the existence of over-lapping fields of taxation in the various governmental divisions of the state.

This is followed by a discussion of the modern trends in taxation practice, together with their present or prospective adaptation to conditions in Florida. A critical study is made of the proposal to abolish all ad valorem taxes in the state, with the substitution of a general sales tax and other excise taxes.

An analysis is made of the practice of ear-marking the proceeds from particular tax sources for the purpose of supporting selected governmental activities. The paper recommends that a one-fund system of accounting be used as the basis for sound budgeting of strictly state revenues.

The problem of fair and equitable assessment of property for purposes of taxation is attacked and suggestions made looking toward the establishment of a central state-wide authority designed to bring about uniformity in the ideals of property assessment, yet at the same time preserve and safeguard the principle of home rule in the determination of the local rate of taxation.

The allocation of sources of taxation among the various levels of government is advocated; the aim being to make it possible for the people to fix the responsibility for unnecessarily high taxes and extravagance in spending public money. Emphasis is given to the primary responsibility of the central state government for the support of education, the public health, and the highways.

The paper closes with a summation of conclusions and of proposed remedies.

SOCIOLOGY AND THE PRESENT WORLD CRISIS

L. M. Bristol
University of Florida

The sociologist has peculiar advantages in diagnosing the present world crisis in the conflict between democracy in government and a dictatorship; (1) over the sentimentalist in that he has, along with all scientists, the scientific attitude, and uses, so far as possible, the methods of the exact sciences; (2) over the "irrational optimist" in his knowledge of cultural development which gives him perspective

to see the long road ahead that leads to social organization—if such ever comes; (3) over the student of the specialized social sciences in that he studies man and groups in the totality of their activities, relations and interrelations rather than one aspect.

The sociologist who is accurate and consistent in his use of concepts demands, first, that such terms as "democracy in government" and "democracy as a way of life" be defined and brought into working relation, and that the phrase "the American way of life" that is used so glibly in almost every field, be explained and justified.

The sociologist sees the present crisis as a specially acute form of social disorganization, due to multiplicity of interacting causes that have been at work for thousands of years. He gives names to these causes or *processes* as interaction, competition, conflict, combination and cooperation and to the processes involved in the solution of conflict as withdrawal, destruction of opposition, conciliation, compromise, domination. Moreover, the sociologists, knowing the possibilities of the process called "interpenetration" or "creative accommodation", sees also the possibility—eventually—of working out a solution. But he realizes the difficulties of dealing with a man such as Hitler and a nation such as present-day Germany, and knows that whatever the outcome of the present "blitzkrieg", the final solution lies in the distant future.

Those sociologists have a peculiar advantage in dealing with the present world crisis who, in addition to the scientific attitude and procedure, have worked out a scientifically-grounded social philosophy which enables them to see not only life in association as one—but all life as one with certain discernible trends that give hope that man may yet so control himself, social groups and the material universe as to bring about social organization to take the place of the present social disorganization.

The sociologist who is interested in the application of sociological principles to the attainment of a socially-formulated goal, is able to point out the application of several principles to the solution of the present world crisis. Among these may be mentioned the principles suggested by the terms *social self-preservation, social self-advancement* and *adaptive functioning,* and that suggested by the phrase *strain toward consistency in the mores.*

The sociologist may well conclude from his study that there can be no ultimate solution of the present world crisis between democracy as a form of government and as a way of life, on the one hand, and dictatorship with regimentation on the other, until some nation can demonstrate just what is involved in "efficient democracy" and can show the possibility of making democracy so challenging and so satis-

fying that there will be no desire among the people living in this democracy for any other form of government or way of life; so satisfying, in fact, that it will spread by reflective imitation. The attainment of such a goal, in the thought of the applied sociologist, calls for the democratization of the family, of the community, of education, of religion, of industry—and the cooperation of the great mass of individuals and the coordination of a vast number of agencies in the attainment of *the goal of efficient democracy.*

A STUDY OF THE CITY MANAGER SYSTEM OF GAINESVILLE, FLORIDA

Angus M. Laird and Manning J. Dauer
University of Florida

A historical survey introduces the study of the city manager system of Gainesville, Florida. An attempt is made to place the city in its setting from the standpoint of its social, economic, and political organization prior to the adoption of the city manager charter in 1925. The forces which favored and opposed the adoption of the charter are analyzed.

The organization of the new government instituted after the acceptance of this charter is described fully. A chart of the organization is presented, based on charter provisions, ordinances, and administrative regulations. Thereupon a detailed study of the operation of staff departments is given, followed by the same treatment for the line departments.

The study includes evaluations of the financial procedures of the administrative techniques employed in the city government and closes with an evaluation of the operation of the system as a whole.

ON CERTAIN AREA AND VOLUME FORMULAS

N. H. Bullard
St. Lucie County Schools

The author describes geometric and trigonometric processes for deriving formulas for the surface areas and volumes of rings, spheres, segments and sectors of spheres and ellipsoids, cunes (a cune is the portion of a cylinder intercepted between two planes which intersect within the cylinder—from Latin *cuneus*, a wedge), polycunes (a polycune is composed of three or more cunes of the same cylinder or of equal cylinders), segments and sectors of cunes and polycunes, cunoids

(a cunoid is the portion of a cylindroid intercepted between two planes which intersect within the cylindroid), polycunoids, and segments and sectors of cunoids and polycunoids.

FOOD COMPOSITION AS IT AFFECTS ANIMAL BEHAVIOR

E. T. Keenan
Keenan Soil Laboratory, Frostproof

This paper presents the thesis that to develop a normal physical, emotional, and rational race of people requires that the masses of the population be provided with foods containing the vital elements necessary for the building and maintenance of normal human beings. Livestock breeders and handlers know how foods influence the disposition, intelligence, and temperament of animals. Soil conditions that produce feeds that produce superior farm and range cattle should also produce superior human beings. However, much of our food is grown in soil which is deficient in certain important elements. These deficiencies are an important factor in causing much of the disease and abnormality prevalent in the world today.

THE SCIENCE CURRICULUM IN FLORIDA SCHOOLS

Leo L. Boles
Groveland Schools

In a previous paper[1], the author has discussed the science needs and interests of Florida school children. In order to develop a technique of curriculum construction in science, the author sent a list of twenty-five to one hundred true statements in each of seven science fields to the state executive under whom activities lying in that field are administered. Each executive was requested to indicate the ten to fifteen statements he considered most significant to the children in Florida schools. The author then supplemented the statements so chosen with enough additional statements which he deemed important in order to provide twenty facts in each of the seven fields.

A questionnaire was constructed with these 120 items and members of the Florida Academy of Sciences in attendance at the 1939

[1]L. L. Boles, "What Science Should be Taught Children of Florida? Methods of Investigating This Problem," *Proceedings of the Florida Academy of Sciences,* Vol. 4, (1939), pp. 246-51.

Annual Meeting were asked to indicate on a five-point rating scale their estimates of the importance of each statement for inclusion in the science curriculum of Florida schools. On the basis of the sixty-three completely checked lists which were returned the seven subject matter fields were considered important in the following order (starting with the most important): health and medicine, fishing, agriculture, wildlife, meteorology, geology.

The author believes that this type of procedure may offer a clue as to a desirable method of curriculum construction.

FACTORS INVOLVED IN THE FAILURE OF CYCLIC MATING BEHAVIOR IN THE FEMALE GUINEA PIG AND RAT

William C. Young
Yale Laboratories of Primate Biology, Orange Park

When any randomly selected group of guinea pigs or albino rats is placed under observation for the display of cyclic mating behavior a small percentage of animals is found in which the period of sexual receptivity is of short duration or irregular occurrence if it occurs at all.

In guinea pigs which came under observation the failure of heat seemed attributable to some deficiency of pituitary gland stimulation, or, in animals in which pituitary stimulation was normal, to a high threshold to the conditioning action of estrogen, the hormone produced in the developing graafian follicle of the ovary (Young, Dempsey, Myers and Hagquist, Am. J. Anat., vol. 63, 1938).

Rats of this type have been studied in order to determine to what extent the same factors are responsible for the failure of cyclic mating activity in this species, if the types of pituitary failure which were encountered were transitory or likely to be permanent, if any connection exists between such pituitary deficiencies and the sensitivity to estrogen, and if larger quantities of estrogen than those used in the guinea pig would condition the most unresponsive rats for that. The character of pituitary stimulation was evident from the microscopic structure of the ovary and the sensitivity to estrogen was ascertained by means of injections of different quantities of this hormone followed by the corpus luteum hormone, progresserone.

In 11 of 21 animals which had displayed heat only irregularly if at all prior to ovariectomy, the ovarian condition was normal. In the remaining 10 a variety of ovarian abnormalities are seen all of which suggest a deficiency of pituitary stimulation. These abnormalities

which will be described were not necessarily permanent. Indications are that variation in the extent of the abnormality occurs frequently, sometimes in the direction of normality and sometimes in the direction of greater abnormality.

All the rats displayed a low sensitivity to estrogen, but inasmuch as other rats were found in which heat occurred despite the failure of ovulation and normal follicular development, it is concluded that in the animals studied, the basic factor in the failure of heat was the low sensitivity to estrogen.

The significance of this result for the problem of sexual behavior in the female mammal will be discussed.

ECONOMIC ASPECTS OF THE BURKE-WADSWORTH CONSCRIPTION BILL

Robert D. Downes
University of Miami

In Europe, almost every country has adopted the method of maintaining an army by use of the conscription, or draft method. This applies to times of peace as well as war. Until the adoption of the Burke-Wadsworth Conscription Bill, there has never been a peace-time draft of man power for military purposes in the United States.

The history of conscription in our country has been one of vigorous reaction on the part of the conscript. It was so in the War of Independence; it was true in the Civil War; and there were many opponents of the Selective Service Act in 1917-1918. The conscientious objector; the draft dodger; the bounty seeker; and the fraudulent reenlistment are all manifestations of the unwillingness of our citizens to serve in the armed forces under compulsion.

Conscription cannot be solved by so-called "volunteer" conscription, nor can volunteer enlistment and conscription go hand in hand. There has never been a successful volunteer system in this country.

When five million men are transferred from private life to the life of a "private," as in the World War, it creates a tremendous economic upheaval. The buying power of millions of soldiers with a greatly decreased income is certain to cause a disturbance in the business cycle. The bulk of the burden falls on the small business man. There are certain compensation through such factors as the relief of unemployment, but this is not a vital force.

The removal from the consumer goods market of the purchasing

power of two million men from the ages of 21 to 35 is of great consequence to the retail trade. The effect on credit would be one of importance. Small establishments will find it difficult to replace the business lost by drafting of their clientele. The loss in marriage ranks will be a vital force effecting the durable home goods market. However, a peace-time draft will not be as drastic in its effect as will a war-time draft. Installment payments by the drafted soldier will present the problem of repossession. Industry will have much to say about the draft.

The return to private life of the soldier presented a problem that was a vital matter in 1918. Will it be so again?

THE MILLION VOLT ELECTROSTATIC GENERATOR AT THE UNIVERSITY OF FLORIDA

Daniel C. Swanson
University of Florida

A Van de Graaff electrostatic generator designed to operate at a potential as high as a million volts is being developed by the Physics Department at the University of Florida. This generator is enclosed in a cylindrical tank, 8 feet long and 4 feet in diameter, and is to be operated at pressures up to 100 pounds per square inch. The tank is mounted horizontally one end of which is firmly attached to a concrete pier. The rest of the tank is supported by an under-carriage on rails and can be unbolted from the rigid end and rolled back out of the way. The high potential spherical electrode, 28″ in diameter, is suspended from the fixed end of the tank by a horizontal tripod. This tripod is made from three textolite tubes each 52″ in length. An endless belt 128″ in length and 13″ wide carries the electric charge to the high potential electrode. The charge is sprayed onto this belt by a 10,000 volt rectifying unit. A series of aluminum hoops circling the belt system, concentric with the tripod and sphere and equally spaced extends from the high potential electrode to the end of the tank. These aid in splitting up the potential difference between the sphere and ground in such a way as to keep the potential gradient sensibly constant in this region. The ion accelerating tube which has not yet been constructed will extend from the high potential electrode to an opening in the end of the tank and parallel to the belt system. The ion source and its auxiliary equipment will be located in the high potential electrode.

Some preliminary tests have been made on the operation of the generator without placing it in the tank and these tests were highly

satisfactory. We have yet to complete the apparatus for drying the air to be used in the tank, and certain other details before the generator can be operated in the tank under pressure.

This generator is to be used as an aid in instruction in the various Physics courses and as a means of producing high speed ions to be used in the study of artificial radio-active materials and their applications in Biology and Chemistry and also in the study of other nuclear reactions.

EFFECTS OF SOLUTES ON THE INTERMOLECULAR STRUCTURE OF WATER

WALTER MILLETT
University of Florida

The infra-red spectra of concentrated aqueous solutions of twenty-seven salts, two halogen acids, and two strong bases have been studied in the frequency range from 5000 cm^{-1} to 1500 cm^{-1} with the hope of gaining information on the effects of solutes on the associational water bands. In the case of the strong combination frequency near 2100 cm^{-1}, it was found that KF, NH_4F, LiCl, LiBr, $HgCl_2$, $PbCl_2$, $CaCl_2$, and $Ba(OH)_2$ produced increases in frequency; NaCl, KCl, PbCl, KBr, KI, $MgCl_2$, $BaCl_2$, $ZnCl_2$, NH_4Cl, NH_4Br, and NH_4I produced decreases in frequency; while $CdCl_2$, $NiCl_2$, $SrCl_2$, and $CuCl_2$ caused no observable variations. Hydrolysis effects prevented the drawing of any definite conclusions concerning the effects of $FeCl_3$, $AlCl_3$, $SnCl_4$, and NH_4F on the associational water bands. The experimental results are discussed in the light of the Bernal-Fowler theory of the quasi-crystalline structure of liquid water. Interpretation on the basis of definite hydrol polymers is suggested.

A MATHEMATICS PROGRAM FOR JUNIOR COLLEGE TERMINAL STUDENTS

WILLIAM A. GAGER
St. Petersburg Junior College

The paper opens with a general discussion of the primary purposes of a junior college. It is shown that the junior college started out as a preparatory institution for further university work and is still giving too much emphasis to this function. Two-thirds of the junior college students never go to the senior colleges, yet the junior college curriculum is mainly preparatory.

In the field of mathematics the offerings are still chiefly traditional in nature. Many junior college students are not prepared to progress satisfactorily in the traditional mathematics courses. A dual curriculum is therefore proposed: One for the technically-minded students and one of a more useful nature for those who want some collegiate training in mathematical thinking but who do not plan to pursue mathematics beyond the junior college.

The paper presents experimental data that indicate what eight different groups feel should be in a business mathematics course for junior college terminal students. The groups include 829 consumers, mathematics teachers, students, etc., from all parts of the United States.

A general mathematics program for terminal students in junior colleges is suggested.

SUGAR POLICY IN THE EVERGLADES

W. Porter McLendon
University of Tampa

Organization of cane sugar production for the United States market is characterized by a high degree of integration whereby corporations control the cane output in a "one-crop" region. The chief purpose of this production control is to effect an economical coordination between grinding and planting operations. The large fixed capital outlay in plantations and centrales or grinding plants challenges the initiative of corporate management in developing maximum returns. This normally consists of seeking the most economically-sized plant and securing the fullest use of entrepreneurship. Dynamics of technology, human wants and political strategy have directed capital investment. Too little attention has been given the long-run effects of capitalistic sugar expansion in lands of tropical self-sufficiency. Such neglect in the case of Puerto Rico imposes limitations of the immediate exploitation of opportunities in the low-cost sugar bowl of South Florida.

In Puerto Rico, sugar investments changed a self sufficient economy into a specialized capitalistic economy. Dynamics of technology, profits and tariff policy consistently guided the firms toward mechanization and large-scale output. Increased subsistence accorded the natives, still possessed of feudal customs and living standards, resulted in a marked population growth. Chronic unemployment has been the inevitable consequence.

Since 1929, technical advance and corporate initiative have made the Florida Everglades a low-cost cane producer. A single firm, the United States Sugar Corporation, is responsible for approximately 95% of the total output. Since the Everglades was one of America's unsettled frontiers, the social conditions of a native population did not emerge as a problem. In a short period, the corporation has used scientific research and mechanization to attain a high degree of proficiency. While less than one per cent of the nation's sugar is yet produced in Florida, expansion is blocked, at least temporarily, by a protective quota system. The corporation urges that its low costs of production entitle it to a larger quota at the expense of Puerto Rico and other areas where low standards of living prevail. This proposal is expedient from the standpoint of the corporation and its immediate profits but it overlooks the economic and social effects that its adoption would entail.

It is here proposed that intelligent sugar policy from the national standpoint requires more than merely seeking the most effective use of our scarce resources. Limitations of past capitalistic errors and their gradual adjustment may temporarily justify qualification of what would be expected in a regime of free competitive prices.

REPORT OF THE SECRETARY

During the year 1940 the membership of the Academy has again shown a small increase, as it has in every year since the Academy was founded. The membership today stands at 383; a year ago it was 321. It should be noted that only members in good standing are included in the figures; no person who has resigned or been dropped from membership for non-payment of dues is included.

In addition to its sessions held in connection with the Annual Meeting, the Council has held two meetings during the year—one in the spring at St. Petersburg and one in the fall at Gainesville. Each of these meetings lasted all day and was attended by practically all the members of the Council.

The $50 Research Grant for 1940 has been awarded by the Council to E. M. Miller, University of Miami, for use in connection with his study of the distribution of termite types in Florida, with emphasis on ecological aspects.

Academy members have no doubt noticed that Volume 4 of the *Proceedings* shows further improvements in format over previous volumes. Much of the credit for this excellent work belongs to Mr. Crawford Solomon of the Convention Press, Jacksonville, who are now our printers. The publication of a volume of scientific papers involves many difficulties of which those who have not participated in such a task may not be aware. Mr. Solomon and the staff of the Convention Press have been patient and untiring and have cooperated to the fullest degree with the Editorial Board in its efforts to produce an attractive publication.

The volume of material which has become available for publication in the *Proceedings* has increased considerably. Although Volumes 1, 2, and 3 had only 170, 100, and 156 pages, respectively, Volume 4 jumped to 310 pages and the indications are that Volume 5 will be even larger. Perhaps the Academy should begin to take under consideration the possibility of converting the *Proceedings* from an annual into a quarterly. There are certain simplifications in the editorial task which are possible in a quarterly but which involve considerable difficulty in an annual when it has grown to the present size of the *Proceedings*. There are other obvious advantages, as well as some disadvantages to such a change. All of these will, of course, need careful consideration before a change is made.

J. H. Kusner, *Secretary.*

REPORT OF THE TREASURER

(As of November 15, 1940)

INCOME:			
I. Balance carried forward from November 15, 1939		$586.22	
			586.22
II. Dues Received:			
A. 1937 1 membership	2.00		
1938 5 memberships	10.00		
1939 76 memberships	152.00		
1940 203 memberships	406.00		
1941 6 memberships	12.00		
1941 1 membership part payment	1.00		
		583.00	
B. 1939 4 associate memberships	4.00		
1940 8 associate memberships	8.00		
1941 2 associate memberships	2.00		
		14.00	597.00
III. Institutional Sustaining Memberships			35.00
IV. Receipts from Sale of Proceedings			8.50
V. Receipts from Authors:			
A. Reprints	283.48		
B. Engravings	16.90		
C. Postage	1.25		
		301.63	
			301.63
TOTAL			1528.35
DISBURSEMENTS:			
I. Publication of Proceedings Vol. 3:			
A. Printing	685.08		
B. Reprints	101.00		
C. Engravings	66.78		
			852.86
II. Administrative Expense:			
A. Office of Secretary	160.69		
B. Office of Treasurer	38.39		
C. Printing of programs (1939 meeting)	29.50		
			228.58
III. Miscellaneous:			
A. Bank charges	1.10		
B. Sketches in preparation of seal	7.50		
C. Refund to Mr. Robert, St. John	1.00		
			9.60
TOTAL			1090.94

TOTAL RECEIPTS	1528.35
TOTAL DISBURSEMENTS	1090.94
BALANCE	437.41

ACCOUNTS RECEIVABLE:		
I. Proceedings sold		5.50
II. Reimbursements from Authors		142.65
III. Institutional Memberships		275.00
IV. Regular Memberships:		
A. 1938	32.00	
B. 1939	72.00	
C. 1940	240.00	
		344.00
TOTAL		767.05
ACCOUNTS PAYABLE:		
Service Engraving Company		74.60
Pepper Printing Company		34.00
		108.60

BURTON FAUST, *Treasurer.*

PROGRAM OF THE SECOND ANNUAL MEETING OF THE JUNIOR ACADEMY OF SCIENCES

Fellowship Room, First Avenue Methodist Church
St. Petersburg, Fla.—Nov. 23, 1940, at 9 o'clock

1. Address of Welcome, G. V. Fuguitt, Superintendent of Public Instruction, Pinellas County.
2. Message from the Florida Academy of Sciences, W. L. MacGowan, Chairman Junior Academy Committee, Supervisor of Biology, Jacksonville.
3. "Orchidaceae of West Central Florida," William Amick, Jr., St. Petersburg High School.
4. "The Use of Petroleum in Modern Warfare", Norman Allen, Plant High School, Tampa.
5. "Chemistry and Cosmetics", Orsell Meredith, St. Petersburgh High School.
6. "Plastics: a Great Industry of the Future", Charles Nulter, Plant City High School.
7. "The Central American Boa", Craig Phillips, St. Petersburg High School.
8. "Equipment for a Home Dark Room", Horace Lazo, West Junior High School, Tampa.
9. "The High School Camera Club", Martha Teeter, Winter Haven High School.
10. "Infra-red Photography", Earl Boozer, Winter Haven High School.
11. "The Use of Filters in Photography", Russell Thompson, Winter Haven High School.
12. "The Development of Modern Methods of Resuscitation", Joe Johnson, Bruce Fisher, John Nodine, Clearwater High School.
13. Business Session.

PROGRAM OF THE FIFTH ANNUAL MEETING

ST. PETERSBURG JUNIOR COLLEGE

NOVEMBER 22 AND 23, 1940

FRIDAY, NOVEMBER 22

9:30-10:30 A. M.—1st GENERAL SESSION—Dining Room
President R. C. Williamson presiding

1. Sociology and the Present World Crisis—L. M. Bristol, Professor of Sociology, University of Florida. 15 min.
2. Unscrambling the Vitamins—L. L. Rusoff, Assistant Professor of Animal Nutrition, University of Florida. 20 min.
3. Food Composition as it Affects Animal Behavior—E. T. Keenan, Keenan Soil Laboratory, Frostproof. 10 min.
4. Florida's Tax Problem—George P. Hoffman, Assistant Professor of Mathematics, Florida Southern College. 20 min.

10:30-10:45 A. M.—INTERMISSION

10:45 A. M.-12:15 P. M.—BIOLOGICAL SCIENCES SECTION—Dining Room
Chairman Frances L. West presiding

5. A New Species of Hammerhead Shark of the Genus Sphyrna—Stewart Springer, Bass Biological Laboratory, Englewood. 10 min.
6. Factors Involved in the Failure of Cyclic Mating Behavior in the Female Guinea Pig and Rat—William C. Young, Yale Laboratories of Primate Biology, Orange Park. 20 min.
7. Taxonomy and Distribution of Florida Spongillidae—Margaret C. Johnson, Graduate Student, University of Florida. 15 min.
8. Notes on the Emergence and Life History of the Dragonfly Pantala Flavescens—C. Francis Byers, Assistant Professor of Biology, University of Florida. 10 min.
9. Parasites of Fresh-Water Fish of Southern Florida—Ralph V. Bangham, Professor of Biology, College of Wooster, Wooster, Ohio. By title.
10. On the First Pleopod of the Male Cambari—Horton H. Hobbs, Jr., Instructor in Biological Sciences, University of Florida. By title.
11. Notes on the Distribution and Habits of the Ferns of Northern Peninsular Florida—Stephen H. Spurr, Technical Assistant, Harvard Forest, Harvard University. By title.

10:45 A. M.-12:15 P. M.—PHYSICAL SCIENCES SECTION—Music Room.
Chairman Guy Waddington presiding

12.—An Improved Method for Determining Prime Factors—Guy G. Becknell, Professor of Physics, University of Tampa. 15 min.

13. Florida's Geological Structure and Gravity—Robert B. Campbell, President Peninsular Oil and Refining Company, Tampa. 12 min.

14. The Million Volt Electrostatic Generator at the University of Florida—D. C. Swanson, Instructor in Physics, University of Florida. 20 min.

15. The Chemical Seasoning of Lumber—H. S. Newins, Director, School of Forestry, University of Florida. 15 min.

10:45 A. M.-12:15—P. M.—SOCIAL SCIENCES SECTION—Fellowship Hall, Methodist Sunday School Building
(Across Street from Suwanee Hotel)
Chairman R. F. Bellamy presiding

16. Citrus Marketing Trends—Frederick K. Hurdy, Professor of Economics, Florida Southern College. 15 min.

17. Loss Leaders as Weapons of Monopolistic Competition—Renhold P. Wolff, Assistant Professor of Economics, University of Miami. 15 min.

18. A Re-examination of Freudian Symbolism—Raymond F. Bellamy, Professor of Sociology, Florida State College for Women. 20 min.

19. A Study of the City Manager System of Gainesville, Florida—Angus M. Laird, Assistant Professor of Social Sciences, and Manning J. Dauer, Assistant Professor of History and Political Science, University of Florida. 15 min.

20. Population Changes and Social-Economic Adjustments in Florida, 1880-1940—John M. Maclachlan, Associate Professor of Sociology, University of Florida. By title.

1:30-3:00 P. M.—2nd GENERAL SESSION—Dining Room
President R. C. Williamson presiding

21. Petroleum Exploration Methods—Robert B. Campbell, President, Peninsular Oil and Refining Company, Tampa. 20 min.

22. Economic Aspects of the Burke-Wadsworth Conscription Bill—Robert B. Downes, Instructor in History, University of Miami. 10 min.

23. Discussion: Florida and the National Defense Program. Led by Carl D. Brorein, Chairman, Florida Survey Committee for National Defense. 30 min.

3:00-3:15 P. M.—INTERMISSION

3:15-4:30 P. M.—SOCIAL SCIENCE SECTION—Music Room
Chairman R. F. Bellamy presiding

24. Sugar Policy in the Everglades—W. Porter McLendon, Associate Professor of Economics, University of Tampa. 15 min.

25. Early Railroad and Banking Projects in Florida—J. G. Eldridge, Professor of Economics, University of Florida. 20 min.

26. Should Banks Be Permitted to Fail?—F. W. Tuttle, Assistant Professor of Economics, University of Florida. 20 min.

3:15-4:30 P. M.—Joint Meeting, BIOLOGICAL AND PHYSICAL SCIENCES SECTIONS—Dining Room
Chairman Frances L. West, Biological Sciences Section, presiding

27. The Limnology of a Small Deep Florida Lake—W. J. Harkness, Professor of Biology; E. Lowe Pierce, Graduate Student, University of Florida. 10 min.

28. The Relation Between the Chemical Properties and Availability of Plant Nutrients—O. C. Bryan, Technical Director, Soil Science Cooperative, Florida Southern College. 10 min.

29. Tests and Standards for Shark Liver Oil from Sharks Caught in Florida Waters—L. L. Rusoff, Assistant Professor of Animal Nutrition, University of Florida; Robert M. French, President, Shark Industries, Inc., Hollywood. 5 min.

30. Source Material—Florida Aboriginal Artifacts—J. Clarence Simpson, Florida Geological Survey, Tallahassee. 15 min.

31. What Science Should Be Taught the Children of Florida? Part II.—Leo L. Boles, Supervising Principal, Groveland Public Schools. 10 min.

4:30-6:00 P. M.—Swimming in the Gulf of Mexico and the pool of the Bath Club, Redington Beach

(Admission: 25c)

(Directions for reaching the Bath Club are on page 4)

6:00-6:30 P. M.—Water Sports Program. Bath Club Pool

7:00 P. M.—BANQUET—(Informal)—Bath Club

Toastmaster: B. R. Reinsch, Florida Southern College, Past President of the Academy.

Address of Welcome: Robert B. Reed, President, St. Petersburg Junior College.

Retiring Presidential Address: R. C. Williamson, University of Florida, President of the Academy.

Presentation of the Achievement Medal for 1939: L. Y. Dyrenforth, St. Luke's Hospital, Jacksonville, Chairman of the Medal Committee.

8:30-9:30 P. M.—Motion Pictures. Bath Club

Shown by L. L. Rusoff, Assistant Professor of Animal Nutrition, University of Florida

Rickets in Calves—A silent film on the Vitamin D requirements of calves and the comparative effectiveness of irradiated yeast and cod liver oil concentrate.

Vitamins on Parade—A color-sound film on vitamins and the part they play in the health and growth of poultry.

9:30 P. M.—ARCHEOLOGICAL GROUP—Tides Hotel (next to Bath Club)

W. W. Ehrmann, Assistant Professor of Physical Sciences, University of Florida, presiding

A meeting of those interested in archeology to discuss plans for the development of Florida archeology.

SATURDAY, NOVEMBER 23

8:30-9:55 A. M.—BIOLOGICAL SCIENCES SECTION—Dining Room

Chairman Frances L. West presiding

32. The Taxonomic Status of Pinus Caribaea Mor.—Wilbur B. DeVall, Teaching Fellow in Forestry, University of Florida. 12 min.

33. Suggestions in Technique for the Biological Laboratory (with Demonstrations) —George G. Scott, Emeritus Professor of Biology, College of the City of New York. 10 min.

34. Visual Education in the Biological Sciences—Jay F. W. Pearson, Professor of Zoology, University of Miami. 15 min.

35. A Rust of Florida Pines Caused by Cronartium quercuum (Berk.) Miya—George F. Weber, Plant Pathologist, Agricultural Experiment Station, University of Florida. 5 min.

36. Discussion: Biological Sciences Aspects of the National Defense Program. 25 min.

8:30-9:55 A. M.—PHYSICAL SCIENCES SECTION—Music Room
Chairman Guy Waddington presiding

37. Heavy Minerals in the Beach Sands of Florida—Williard B. Phelps, Associate Professor of Geology, University of Tampa. 20 min.

38. Effect of Solutes on the Intermolecular Structure of Water—Walter Millett, Student, University of Florida. 10 min.

39. On Certain Area and Volume Formulas—N. H. Bullard, Superintendent of Public Instruction, St. Lucie County. 20 min.

40. Discussion: Physical Sciences Aspects of the National Defense Program. 20 min.

8:30-9:55 A. M.—SOCIAL SCIENCES SECTION—Ballroom
Chairman R. F. Bellamy presiding

41. The Anglo-French Rivalry in Siam, 1902-04—G. Leighton LaFuze, Professor of History and Political Science, Stetson University. 25 min.

42. Hemisphere Defense and Inter-American Cooperation—Sigismond deR. Diettrich, Assistant Professor of Economic Geography, University of Florida. 20 min.

43. Discussion: Social Sciences Aspects of the National Defense Program. 20 min.

10:00-11:40 A. M.—3rd GENERAL SESSION—Ballroom
President R. C. Williamson presiding

44. The Function of a Supreme Court in American Constitutional Government—James Miller Leake, Professor of History and Political Science, University of Florida. 15 min.

45. Chemical Integrative Mechanism in Social Insect Society—E. M. Miller, Assistant Professor of Zoology, University of Miami. 25 min.

46. Solution, A Dominant Factor in Shaping the Physiography of Peninsular Florida—Sidney A. Stubbs, Assistant State Geologist, Florida Geological Survey, Tallahassee. 20 min.

47. A Mathematical Program for Junior College Terminal Students—William A. Gager, Professor of Mathematics, St. Petersburg Junior College. 20 min.

11:45 A. M.-12:15 P. M.—BUSINESS SESSION—Ballroom

12:15-1:00 P. M.—MEETING OF 1941 COUNCIL—Flamingo Room

1:15 P. M.—Tarpon Springs Trip

1:30 P. M.—St. Petersburg Trip

6:30 P. M.—Dinner—Florida Section, American Chemistry Society
(Academy members are invited to attend.) Nikko Inn, 19 First Street North.

7:30 P. M.—Business Meeting—Florida Section, American Chemical Society, Nikko Inn.

8:30 P. M.—JOINT MEETING—Biological and Physical Sciences Sections of the Academy and Florida Section of the American Chemical Society. Auditorium, St. Petersburg Junior College.

President Fred H. Heath, Florida Section, American Chemical Society, presiding

Address: Some Studies of Insect Physiology—Frank H. Babers, Associate Biochemist, Bureau of Entomology and Plant Quarantine, Beltsville, Md.

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PAST-PRESIDENT—(1939)—B. P. Reinsch, *Florida Southern College.*

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CHAIRMAN OF COMMITTEE ON SUSTAINING MEMBERSHIP AND ENDOWMENTS—R. B. Campbell, *Peninsular Refining Company, Tampa.*

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CHAIRMAN OF COMMITTEE ON JUNIOR ACADEMY—W. L. MacGowan, *Lee High School, Jacksonville.*

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CHAIRMAN, PHYSICAL SCIENCES SECTION—Harold F. Richards, *Florida State College for Women.*

CHAIRMAN, SOCIAL SCIENCES SECTION—Kathryn Abbey, *Florida State College for Women.*

ADDITIONAL MEMBERS OF THE COUNCIL

PAST PRESIDENT, 1940—R. C. Williamson, *University of Florida.*

PAST PRESIDENT, 1939—B. P. Reinsch, *Florida Southern College.*

EDITOR OF THE PROCEEDINGS—L. Y. Dyrenforth, *St. Luke's Hospital, Jacksonville*

CHAIRMAN OF COMMITTEE ON SUSTAINING MEMBERSHIP AND ENDOWMENTS—Robert B. Campbell, *Peninsular Oil and Refining Co., Tampa.*

CHAIRMAN OF CONSERVATION COMMITTEE—S. A. Stubbs, *State Geological Survey.*

CHAIRMAN OF JUNIOR ACADEMY COMMITTEE—Mrs. Marie B. Gager, *St. Petersburg High School.*

CHAIRMAN OF LOCAL ARRANGEMENTS—R. V. Sowers, *Florida Southern College.*

MEMBERS - 1940

Abbey, Kathryn T., Florida Medical Center, Care of Dr. A. J. Hanna, Rollins College (History)
Albee, Fred H., 49 West Duval Street, Venice (Medicine)
Albert, Franklin E., Jacksonville (Social Sciences)
Alexander, T. R., University of Miami (Botany)
Allen, E. Ross, Florida Reptile Institute, Silver Springs (Herpetology)
Anderson, Arthur, Florida Southern College (Economics)
Anderson, George W., 31 W. Park Place, Stanford, Conn. (Chemistry)
Anderson, Richard J., 2322 Herschell Street, Jacksonville (Mathematics)
Anderson, W. S., Rollins College (Chemistry)
Annis, E. R., Florida State College for Women (Medicine, Surgery)
Applin, Esther R., 2317 West Magnolia Avenue, Fort Worth, Texas (Geology)
Armstrong, J. D., Bryceville (Chemistry)
Arnold, Lilian E., Agr. Exp. Station, University of Florida (Taxonomic Botany)
Atwood, Rollin S., University of Florida (Geography)

Babcock, L. L., M. & T. Building, Buffalo, N. Y. (Ichthyology)
Bacon, Milton E., Jr., Wakulla (Archeology, Aeology)
Bangham, Ralph V, College of Wooster, Wooster, Ohio (Parasitology)
Barbour, R. B., 656 Interlachen Avenue, Winter Park (Organic Chemistry)
Barbour, Thomas, Museum of Comparative Zoology, Harvard University, Cambridge, Mass. (Zoology)
Beatty, I. Croom, III, Rollins College (Chemistry)
Beck, Dow G., 2618 Algonquin Avenue, Jacksonville (Physics)
Becker, R. B., Agr. Exp. Station, University of Florida (Agriculture)
Becker, H. F., Florida State College for Women (Geography)
Becknell, Elizabeth A., 6900 Dixon Avenue, Tampa (Psychology)
Becknell, G. G., University of Tampa (Physics, Mathematics)
Belcher, Vera, Leon High School, Tallahassee (Biology)
Bell, C. E., Agr. Exp. Station, University of Florida (Chemistry)
Bellamy, R. E., 9 Hardeman Bldg., Macon, Ga. (Biology)
Bellamy, R. F., Florida State College for Women (Sociology)
Benn, Donald G., St. Petersburg Junior College (Economics)
Bentley, George R., University of Wisconsin, Madison, Wis. (History)
Berger, E. W., Agr. Exp. Station, University of Florida (Entomology)
Best, Albert H., University of Florida (Chemistry)
Blackmon, G. H., Agr. Exp. Station, University of Florida (Horticulture)
Blair, W. Frank, Laboratory of Vertebrate Genetics, University of Michigan, Ann Arbor, Mich. (Genetics)
Blake, Robert G., Brooksville High School (Mathematics)
Bless, A. A., University of Florida (Physics)
Blount, Mildred, 2245 Eighteenth Street North, St. Petersburg (General Science)
Bly, R. S., Florida Southern College (Chemistry)
Bode, Donald D., University of Tampa (Chemistry)
Boles, Leo L., 4100 Granny White Road, Nashville, Tenn. (Chemistry)

Boleik, Irene, Florida State College for Women (Zoology)
Boyd, M. F., State Board of Health, Tallahassee (Epidermiology)
Brackett, Alice W., St. Petersburg Senior High School (Chemistry)
Brannon, Melvin A., University of Florida (Algology)
Breder, C. M., Jr., New York Aquarium, Battery Park, N. Y. (Ichthyology)
Briley, Beulah B., Florida State College for Women (Social Sciences)
Bristol, Margaret C., Florida State College for Women (Social Sciences)
Bristol, L. M., University of Florida (Sociology)
Bruce, Malcolm, Thomas Hotel, Auburn, Ala.
Bryan, O. C., Florida Southern College (Pedology)
Buckland, Charlotte B., Landon High School, Jacksonville (Biology)
Bullard, N. H., Supt. of Public Instruction, Ft. Pierce (Mathematics)
Burlingham, Gertrude S., 818 Antionette Avenue, Winter Park (Mycology)
Buswell, W. M., University of Miami (Botany)
Butler, P. A., Medical Detachment, Station Hospital, Camp Blanding (Curator)
Byers, C. F., University of Florida (Biology)

Calaway, Wilson T., 1674 S. W. 23rd Street, Miami (Chemistry)
Campbell, Robert B., 603 Wallace S. Building, Tampa (Geology)
Cantral, Irving J., Museum of Zoology, University of Michigan, Ann Arbor, Mich. (Zoology)
Carleton, W. G., University of Florida (History, Political Science)
Carrigan, R. A., Agr. Exp. Station, University of Florida (Chemistry)
Cartwright, George H. C., 626 Chase Avenue, Winter Park (Acoustics)
Case, Shirley Jackson, Florida Southern College (Religion)
Chace, James Edward, Jr., Tallahassee (Labor, Personnel)
Chandler, H. W., University of Florida (Mathematics)
Chase, Randall, Box 291, Sanford (Agricultural Sciences)
Clouse, J. H., University of Miami (Physics)
Coe, Samuel G., Florida Southern College (Social Sciences)
Conn, John F., Stetson University (Chemistry)
Connor, Ruth, Florida State College for Women (Home Economics)
Conradi, Edward, Florida State College for Women (Psychology)
Cooper, W. C., U. S. Dept. of Agriculture, Orlando (Plant Physiology)
Cooper, Hilton H., Jr., Florida Geological Survey, Tallahassee (Hydrology)
Corse, Carita Doggett, 1801 Goodwin Street, Jacksonville, (History)

Dauer, Manning J., University of Florida (History, Political Science)
Davis, Barbara, Apopka, or 22 Harris Sreet, Greenville, S. C. (Mathematics, Physics)
Davis, E. M., Baker Museum, Rollins College (Ornithology, Entomology)
Davis, Katherine, P. O. Box 402, Homestead (Psychology, Botany)
Davis, U. P., University of Florida (Mathematics)
Dell, Mrs. R. G., Bronson, (Zoology)
Demaree, Dilzie, A. & M. College, Monticello, Ark. (Plant Ecology)
DeMelt, W. E., Florida Southern College (Psychology)
DeVall, Wilbur B., University of Florida (Forestry)

Deviney, Ezda, Florida State College for Women (Zoology)
Dickenson, J. C., Jr., University of Florida (Biology)
Diettrich, S. deR., University of Florida (Geography)
Disher, Dorothy R., Florida State College for Women (Psychology)
Dolbeare, H. B., University of Florida (Economics)
Dostal, B. F., University of Florida (Mathematics)
Downes, R. B., University of Miami (History)
Drosdoff, Matthew, 146 Florida Court, Gainesville (Soil Science)
Dumas, Vera M., St. Petersburg Junior College (Education)
Durham, W. Clarence, P. O. Box 739, Gainesville (Science, Mathematics)
Dyrenforth, L. Y., St. Lukes Hospital, Jacksonville (Medicine)

Eddy, Paul, State Dept. of Education, Tallahassee (Education)
Edwards, Richard A., University of Florida (Geology)
Ehrmann, W. W., University of Florida (Sociology)
Eldridge, J. G., University of Florida (Economics)
Elliott, John E., 3404 Yoakum Blvd., Houston, Texas (Petroleum Geology)
Emersen, Mary P., St. Petersburg High School (Ornithology)
Erck, G. H., Weirsdale (Agriculture)
Everett, Helen, Florida Southern College (Biological Sciences)

Fairchild, David, University of Miami (Agriculture)
Fargo, W. G., Dec. through April: P. O. Box 874, Pass-a-Grille Beach; May through Dec., 506 Union Street, Jackson, Mich. (Ornithology)
Faust, Burton, 815 Olympia Building, Miami (Physics, Mathematics)
Fernald, H. T., 1128 Oxford R., Winter Park (Entomology)
Fifield, W. M., University of Florida (Agriculture)
Fike, Ruth, Florida Southern College (Mathematics)
Finner, Paul F., Florida State College for Women (Psychology)
Floyd, B. F., Davenport (Horticulture)
Floyd, W. L., University of Florida (Agriculture)
Foote, P. A., University of Florida (Pharmacy)
Fraser, Morris, Englewood (Histology)
Frash, Edwin S., University of Florida (Engineering)
Freeman, Ellis, University of Tampa (Psychology)
French, Robert M., Shark Industries, Inc., Hollywood (Biology)
Frink, Inez, Florida State College for Women (Social Sciences)
Funk, Arthur L., St. Petersburg Junior College (Social Sciences, History)

Gaddum, L. W., University of Florida (Biochemistry)
Gager, Marie B., St. Petersburg High School (Biology)
Gager, William A., St. Petersburg Junior College (Mathematics, Psychology)
Garvin, Carolyn F., Florida Southern College (Biological Sciences)
Gay, Arthur W., St. Petersburg Junior College (Chemistry)
Gay, Marjorie Anderson, St. Petersburg High School (Chemistry, Physics)
Gaylord, Richard, University of N. C., Chapel Hill (Psychology)
Gentry, V. S., Florida Southern College (Zoology)

Germond, H. H., University of Florida (Mathematics)
Gifford, John C., University of Miami (Forestry)
Gist, M. N., Box 7, McIntosh, (Natural History)
Goin, Coleman, University of Florida (Biology)
Goldstein, Robert C., 405 Dryden Rd., Ithaca, N. Y. (Herpetology)
Graham, Viola, Florida State College for Women (Physiology)
Gratz, L. O., Agr. Exp. Station, University of Florida (Plant Pathology)
Griffin, John Wallace, 309 N. Grandview Avenue, Daytona Beach (Anthropology)
Grout, A. J., New Fane, Vermont (Bryology)
Gunter, Herman, Florida Geological Survey, Tallahassee (Geology)
Gut, H. James, P. O. Box 700, Sanford (Paleontology)

Hadley, A. H., 136 Arlington Way, Ormond Beach (Ornithology)
Hall, Lydia Sue B., 1235 Challen Avenue, Jacksonville (Chemistry, Biology)
Hamilton, H. G., University of Florida (Social Sciences)
Hanna, A. J., Rollins College (History, Social Science)
Hanover, F. J., Florida State College for Women (Social Sciences)
Hardy, Fredrick K., Florida Southern College (Economics, Social Sciences)
Harkness, William J. K., University of Florida (Biology)
Harper, Roland M., University Alabama (Plant Geography)
Harrison, R. W., 2337 N. W. Flagler Terrace, Miami
Hart, Sister Mary Jane, O. P., Barry College, P. O. Box B, Little River Station, Miami (Chemistry)
Hawkins, J. E., University of Florida (Chemistry)
Hayward, Wyndham, Winter Park (Horticulture)
Heinlein, C. P., University of California, Los Angeles, Cal. (Psychology)
Heinlein, Julia H., University of California, Los Angeles, Cal. (Psychology)
Hinckley, E. D., University of Florida (Psychology)
Hjort, E. V., University of Miami (Chemistry)
Hobbs, H. H., Jr., University of Florida (Biology)
Hoffman, George P., Florida Southern College (Mathematics, Physical Sciences)
Holdsworth, J. T., University of Miami (Economics, Finance)
Hood, Mary Noka, Florida State College for Women (Bacteriology)
Hopkins, A. E., Fisheries Biological Station, Pensacola (Biology)
Hubbell, T. H., University of Florida (Biology)
Hull, F. H., University of Florida (Genetics)
Hume, H. H., University of Florida (Botany)

Imeson, C. V., P. O. Box 393, Chattahoochee (Chronology)
Irish, Marian Doris, Florida State College for Women (Political, Social Sciences)

Jackson, Elizabeth S., Florida Southern College (Sociology)
Jacobs, M. Louise, Holt Junior High School (Botany)
Johnson, A. L. P., University of Tampa (Political, Social Sciences)
Johnson, Margaret C., 300 N. 7th Street, Gainesville (Biology)
Johnson, Richard S., University of Florida (Education)

Keenan, E. T., Frostproof (Soil Chemistry)
Keene, Jesse L., University of Tampa (Political, Social Sciences)
Kelly, Howard A., 1406 Eutaw Place, Baltimore, Md. (Medicine)
Kew, Theodore J., Rollins College (Chemistry)
Kinser, B. M., Eustis (Geology, Astronomy, Zoology)
Kinsler, L. E., Rollins College (Physics)
Knorr, J. Francis, Jr., Stetson University (Astronomy)
Kurz, Herman, Florida State College for Women (Botany)
Kusner, J. H., University of Florida (Mathematics, Astronomy)

La Fuze, G. L., Stetson University (History, Political, Social Sciences)
Lagassee, Felix S., Tung Oil Lab., University of Florida
Larson, Olga, Florida State College for Women (Mathematics)
Leake, J. M., University of Florida (History, Political Sciences)
Lehner, George, University of Miami (Psychology, Biology)
Leigh, T. R., University of Florida (Chemistry)
Lewis, Kenneth, St. Petersburg High School (Physics)
Long, Winifred O., 2030 43rd Street South, St. Petersburg (Botany, Zoology, Geology, Ornithology)
Longstreet, Rupert J., 610 Braddock Avenue, Daytona Beach (Psychology, Ornithology)
Lutz, Nancy E., San Jose Blvd., Jacksonville (Botany)
Lyerly, J. G., 516 Greenleaf Building, Jacksonville (Neurological Surgery)
Lynch, S. J., Sub-Tropical Exp. Station, Homestead (Sub-Tropical Horticulture)
Lynn, Edith E., Florida State College for Women (Physics)

McBride, Arthur, Marine Studios, Marineland (Biology)
McCallister, Martha E., Child's Park Elementary Schools, Pinellas Park (Biological Social Sciences)
McCracken, E. M., University of Miami (Government, Social Sciences)
McDonald, Walter H., 4324 Notter Street, Jacksonville (Social Sciences)
McFarlin, J. B., Florida Botanical Garden and Arboretum, Sebring, (Taxonomic Botany, Bryology, Horticulture)
McFerrin, J. B., University of Florida (Social Sciences)
MacGowan, W. LeRoy, Robert E. Lee High School, Jacksonville (Biology)
McKellar, P. D., Jackson, Minnesota (Vertebrate Paleontology)
McKinnel, Isabel, Florida State College for Women (Chemistry)
McKinney, Robert S., Tung Oil Laboratory, West Main South, Gainesville
McLendon, W. Porter, University of Tampa (Economics, Social Sciences)

Maier, Eugene, Florida Medical Center, Venice (Bacteriology, Biology, Chemistry)
Manchester, James G., 216 Sixteenth Avenue Northeast, St. Petersburg (Mineralogy)
Manley, Louis K., University of Miami (Political Sciences)
Marquis, Sister Patricia Ann, O. P., Rosarian Academy, West Palm Beach (Biology)

Matherly, W. J., University of Florida (Economics)
Mattice, Royal, Florida State College for Women (Economics)
Meehean, O. L., U. S. Bureau of Fisheries, Welaka (Zoology, Conservation)
Mendenhall, H. D., Florida State College for Women (Engineering)
Menneken, Carl E., Miami Beach Senior High School (Physics)
Meyer, Max F., University of Miami (Psychology)
Miller, Dorothy B., University of Miami (Zoology)
Miller, E. Morton, University of Miami (Zoology)
Miller, J. Kyle, St. Petersburg High School (Botany)
Millett, Walter, Univ. of Fla. (Physics)
Mills, Herbert R., Tampa
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Mowry, Harold, Agr. Exp. Station, University of Florida (Horticulture)
Mull, L. E., Agr. Exp. Station, University of Florida (Dairy Science)
Mulvania, Maurice, Florida Southern College (Botany)
Murray, Mary Ruth, Robert E. Lee Junior High School, Miami

Newell, Wilmon, University of Florida (Agriculture)
Newins, H. S., University of Florida (Forestry)
Nissen, Henry W., Yale Laboratories of Primate Biology, Orange Park (Biology)
Noble, C. V., University of Florida (Agricultural Economics, Social Sciences)
Norris, H. W., Grinnell College, Grinnell, Iowa (Zoology)
Nutter, H. E., U. of F. (Curriculum Development)

Osborn, Herbert, Rollins College (Zoology, Entomology)

Parker, Gerald G., 234 E. 14th St., Hialeah (Geology)
Parker, Horatio N., 2777 Park St., Jacksonville (Public Health)
Pearson, Hazel M., 223 Avenue Calabria, Coral Gables (Ecology)
Pearson, J. F. W., University of Miami (Zoology)
Pearson, Walter M., University of Tampa (Protozoology)
Penningroth, Paul W., St. Petersburg Junior College (Psychology)
Perry, Louise M., Sanibel (Marine Biology, Ornithology)
Perry, W. S., University of Florida (Physics)
Phelps, Willard B., University of Tampa (Geologist)
Phipps, Cecil G., University of Florida (Mathematics)
Ponton, G. M., 271½ St. George St., St. Augustine (Geology)
Popper, Annie Marie Therese, Florida State College for Women (Social Sciences)
Price, J. E., University of Florida (Personnel & Guidance, Politics, Social Sciences)

Raa, Ida, Leon High School, Tallahassee, (Chemistry)
Reed, J. Paul, University of Miami (Sociology)
Reed, Robert B., St. Petersburg Junior College (History, Social Sciences)
Reeves, Gordon C., P. O. Box 441, Jacksonville (History, Social Sciences)
Reinsch, B. P., Florida Southern College (Mathematics, Physics)
Rense, W. A., University of Miami (Physics)

Richards, Harold F., Florida State College for Women (Physics)
Robinson, Dana F., Florida Southern College (Religion, Sociology)
Robinson, Winnifred J., 818 Antionette Ave., Winter Park (Botany)
Robinson, T. Ralph, P. O. Box 1058, Orlando
Rogers, J. Speed, University of Florida (Biology)
Rolfs, P. H., 1422 West Arlington St., Gainesville (Botany)
Rusoff, L. L., Agr. Exp. Station, U of F. (Biochemistry)

Sadler, G. G., 315 N. Highland St., Mount Dora (Zoology)
Sandels, Margaret R., Florida State College for Women (Home Economics)
Sanford, Daniel S., University of Tampa (Psychology, Social Sciences)
Savely, Harvey E., Stetson University (Ecology, Physiology, Geology)
Scarborough, Christine, Florida State College for Women (Psychology)
Schmidt, Arthur H., Marine Studios, Marineland (Biology)
Schornherst, Ruth, Florida State College for Women (Botany)
Scott, George Franklin, Florida Southern College (History, Social Sciences)
Scott, George G., 480 Henkel Circle, Winter Park (Biology)
Sell, Harold M., 309 N. Oak St., Gainesville
Senn, P. H., University of Florida (Agronomy)
Shankweiler, P. W., Florida State College for Women (Social Sciences)
Shealy, A. L., Univ. of Fla. (Animal Husbandry)
Sherman, H. B., Univ. of Fla. (Biology)
Sherman, John H., Webber College, Babson Park (Social Sciences)
Shippy, William B., Celery Investigations Laboratory, Sanford (Plant Pathology)
Shores, Venila L., F. S. C. W. (Social Sciences)
Simpson, J. Clarence, Caverns State Park, Marianna
Simpson, T. M., University of Florida (Mathematics)
Smith, Carleton, Madison (History)
Smith, Frank, 2219 7th St. N., St. Petersburg (Zoology, Ornithology)
Smith, F. B., U. of F. (Microbiology)
Smith, Maxwell, Lantana (Biology)
Smith, Richard M., 537 Oakland Ave., Country Club Estate, Tallahassee (Chemistry)
Snider, Eulah Mae, State Library, Tallahassee (Social Sciences)
Sowers, R. V., Florida Southern College (Sociology)
Spivey, Ludd M., Florida Southern College (Sociology)
Springer, Stewart, Florida Marine Products Co., Islamorada (Zoology)
Spurr, J. E., Rollins College (Geology)
Spurr, Stephen H., Harvard Forest, Petersham, Mass. (Forestry)
Stevens, H. E., 224 Annie St., Orlando (Horticulture)
Stiles, C. Wardell, Rollins College, (Zoology)
St. John, Edward P., Floral City (Botany)
St. John, Robert P., Floral City (Crytogamie Botany)
Stokes, W. E., Agr. Exp. Station, U. of F. (Agronomy)
Story, Helen F., St. Petersburg Junior College (Astronomy, Mathematics)
Stubbs, Sidney A., Florida Geological Survey, Tallahassee (Geology)

Summitt, John W., Monticello
Swanson, D. C., University of Florida (Physics)

Tallant, W. M., 1005 Manatee Ave., Manatee (Archeology)
Tanner, W. Lee, 732 N. W. 36th St., Miami (Chemistry)
Tebeau, C. W., University of Miami (History, Social Sciences)
Therrell, J. H., Florida State Hospital, Chattahoochee (Hospital Administration)
Thomas, R. H., 37 South Hogan St., Jacksonville (Electricity)
Tilden, Josephine E., Lake Wales (Botany)
Tilt, Jennie, Florida State College for Women (Chemistry)
Tisdale, W. B., Agr. Exp. Station, U. of F. (Plant Pathology)
Tissot, A. N., Agr. Exp. Station, U. of F. (Entomology)
Tracy, Anna M., F. S. C. W. (Nutrition)
Tryon, Florence, F. S. C. W. (History, Social Sciences)
Tuttle, F. W., U. of F. (Economics, Social Sciences)

Van Brunt, W. E., Telephone Building, Tallahassee (Dentistry)
Van Dusen, A. C., Northwestern University, Evanston, Illinois (Psychology)
Vance, Charles B., Stetson University (Geology)
Vance, Earl L., F. S. C. W. (Journalism)
Vermillion, Gertrude, F. S. C. W. (Chemistry)

Waddington, Guy, Rollins College (Chemistry)
Waite, Alexander, Rollins College, (Psychology)
Walker, Seth S., 1145 E. Cass St., Tampa (Chemistry, Physics)
Wallace, Madge, 3725 Lydia St., Jacksonville (Botany)
Wallace, Howard K., U. of F. (Biology)
Waskom, H. L., F. S. C. W. (Psychology)
Watson, J. R., Agr. Exp. Station, University of Florida (Entomology)
Weber, George F., Agr. Exp. Station, U. of F. (Plant Pathology)
Weil, Joseph, U. of F.
Weir, Marie Catherine, St. Petersburg High School (Biology)
Weltch, Clara, Andrew Jackson High School, Jacksonville (History)
West, Erdman, Agr. Exp. Station, U. of F. (Botany)
West, Frances L., St. Petersburg Junior College (Biology)
White, Sara Parker, F. S. C. W. (Medicine)
Williams, F. D., U. of F. (Physics)
Williams, H. F., University of Miami (History)
Williams, Henry W., Drawer C, Umatilla (Herpetology)
Williams, Osborne, U. of F. (Psychology)
Williamson, B. F., 129 E. Main St., North, Gainesville (Tung Production & Manufacture)
Williamson, R. C., U. of F. (Physics)
Willoughby, C. H., U. of F. (Animal Husbandry)
Wilson, W. H., University of Florida (Mathematics)
Wimberly, Stan. E., U. of F. (Psychology)

Wise, Louis E., Rollins College (Chemistry)
Witmer, Louise R., F. S. C. W. (Psychology)
Wilff, Reinhold P., University of Miami (Economics)

Yothers, W. W., 457 Boone St., Orlando
Young, John W. 720 Glen Ridge Drive, West Palm Beach (Mathematics, Physics)
Young, Sadie G., Florida State College for Women (Economics)
Young, William C., Yale Laboratories of Primate Biology, Orange Park (Biology)

Zandstra, Thomas, F. S. W. C., Tallahassee (Physics)
Ziegler, E. A., University of Tampa (Forestry)
Zielonka, David L., U. of Tampa (Sociology)

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